IMP. BUR. ENTOM.
— LIBRARY —
No. 4823

# BULLETIN

OF

# ENTOMOLOGICAL RESEARCH.

ISSUED BY THE IMPERIAL
BUREAU OF ENTOMOLOGY.

EDITOR: THE DIRECTOR.

VOL. XX

LONDON:
THE IMPERIAL BUREAU OF ENTOMOLOGY,
41, QUEEN'S GATE, S.W.7.
1929.

# IMPERIAL BUREAU OF ENTOMOLOGY.

## HONORARY COMMITTEE OF MANAGEMENT.

**THE EARL BUXTON, G.C.M.G.,** *Chairman.*

Dr. W. Horner Andrews, M.R.C.V.S., Director, Veterinary Laboratory, Ministry of Agriculture and Fisheries.
Major E. E. Austen, D.S.O., Keeper, Entomological Department, British Museum (Natural History).
Dr. A. G. Bagshawe, C.M.G., Director, Bureau of Hygiene and Tropical Diseases.
Mr. C. E. Baines, India Office.
Sir Andrew Balfour, K.C.M.G., C.B., Director, London School of Hygiene and Tropical Medicine.
Major-General Sir David Bruce, K.C.B., F.R.S., Chairman of the Governing Body, Lister Institute.
Dr. P. A. Buxton, University Reader in Medical Entomology, London School of Hygiene and Tropical Medicine.
Mr. J. C. F. Fryer, O.B.E., Director, Pathological Laboratory, Ministry of Agriculture and Fisheries.
Sir Sidney F. Harmer, K.B.E., F.R.S.
Dr. R. Stewart MacDougall, late Reader in Agricultural Entomology, Edinburgh University.
Sir John McFadyean, late Principal, Royal Veterinary College, Camden Town.
Sir Daniel Morris, K.C.M.G., late Adviser to the Colonial Office in Tropical Agriculture.
Mr. J. Murray, C.M.G., Foreign Office.
Emeritus Professor R. Newstead, F.R.S., The University of Liverpool.
Professor G. H. F. Nuttall, F.R.S., Quick Professor of Protozoology, Cambridge.
Mr. A. C. C. Parkinson, O.B.E., Colonial Office.
Professor E. B. Poulton, F.R.S., Hope Professor of Zoology, Oxford.
Lieutenant-Colonel Sir David Prain, C.M.G., C.I.E., F.R.S.
Lieutenant-Colonel Sir R. Eccles Snowden, Agent-General for Tasmania.
Dr. A. T. Stanton, C.M.G., Chief Medical Adviser to the Secretary of State for the Colonies.
Mr. F. A. Stockdale, C.B.E., Asst. Agricultural Adviser, Colonial Office.
Mr. F. V. Theobald, South Eastern Agricultural College, Wye.
Mr. C. Warburton, Zoologist to the Royal Agricultural Society of England.

The Chief Entomologist in each of the Self-governing Dominions is *ex officio* a member of the Committee.

**SECRETARY.**
Mr. G. F. Seel (Colonial Office).

**DIRECTOR.**
Dr. Guy A. K. Marshall, C.M.G., F.R.S.

**ASSISTANT DIRECTOR and EDITOR.**
Dr. S. A. Neave.

**SUPERINTENDENT OF FARNHAM HOUSE LABORATORY.**
Dr. W. R. Thompson.

*Head Office.*—British Museum (Natural History), Cromwell Road, London, S.W. 7.
*Publication Office.*—41, Queen's Gate, London, S.W. 7.

# CONTENTS.

## ORIGINAL ARTICLES.


PAGE

AUSTEN, E. E.
A new Tsetse-fly of the *Glossina palpalis* Group occurring in the Belgian Congo (*illustrated*) ... ... ... ... ... ... 1
The Tsetse-fly Parasites belonging to the Genus *Thyridanthrax* (Diptera—Family Bombyliidae), with Descriptions of new Species (*illustrated*) ... ... ... ... ... ... ... 151
AYYAR, T. V. R.
The economic Status of Indian Thysanoptera ... ... ... 77
BAGNALL, R. S.
On some new and interesting Thysanoptera of economic Importance (*illustrated*) ... ... ... ... ... ... ... ... 69
BARNES, H. F.
Two Gall Midges (Cecidomyidae) found in Stored Products (*illustrated*) ... ... ... ... ... ... ... ... ... 119
Gall Midges (Dipt., Cecidomyidae) as Enemies of Aphids ... ... 433
BARRITT, N. W.
Experiments on the Control of the Pink Boll-worm in Egypt ... 41
A new Spray for Scale-insects on Citrus in Egypt ... ... ... 44
BEATTIE, M. V. F., & HOWLAND, L. F.
The Bionomics of some Tree-hole Mosquitos (*illustrated*) ... ... 45
BODKIN, G. E.
The Locust Invasion of Palestine during 1928 (*illustrated*) ... 123
A Note on the Utility of Aerial Photography in Entomological Field Work (*illustrated*) ... ... ... ... ... ... 431
BOX, H. E.
On the Identity of the common Dipterous Parasite of the Larva of *Diatraea saccharalis*, Fabr., in the Northern Provinces of Argentina ... ... ... ... ... ... ... ... 199
CHINA, W. E.
An Addendum to Mr. F. D. Golding's " Notes on the Bionomics of Cotton Stainers (*Dysdercus*) in Nigeria " ... ... ... ... 38
A new Species of *Bryocoropsis* (Hem., Capsid.) on Cacao in Fernando Póo (*illustrated*) ... ... ... ... ... ... ... 253
CHORLEY, J. K.
The Bionomics of *Glossina morsitans* in the Umniati Fly Belt, Southern Rhodesia, 1922–23 (*illustrated*) ... ... ... ... 279
Experiments in Grass Fires against *Glossina morsitans* in Southern Rhodesia ... ... ... ... ... ... ... 377
DEKHTIAREV, N. S.
Notes on the Scarabaeid Beetles attacking Vines in Ukraine (*illustrated*) ... ... ... ... ... ... ... ... 95
EDWARDS, F. W.
Mosquito Notes.—VIII (*illustrated*) ... ... ... ... ... 321
EVANS, J. W.
New Species of *Nysius* (Hem., Lygaeid.) from South Africa (*illustrated*) ... ... ... ... ... ... ... ... 267
FERRIÈRE, C.
On three new Chalcidoid Parasites of *Platyedra* (*illustrated*) ... 255
The Asiatic and African Species of the Genus *Elasmus*, Westw. (Hym., Chalcid.) ... ... ... ... ... ... ... 411
HALL, W. J.
Observations on the Coccidae of Southern Rhodesia. II & III (*illustrated*) ... ... ... ... ... ... ... 345, 359

PAGE

HODSON, W. E. H.
The Bionomics of *Lema melanopa*, L. (Criocerinae) in Great Britain (*illustrated*) ... ... ... ... ... ... ... ... 5

HOLDAWAY, F. G.
Confirmatory Evidence of the Validity of the Species *Pectinophora scutigera*, Holdaway (Queensland Pink Bollworm), from a Study of the Genitalia (*illustrated*)... ... ... ... ... ... 179

IMMS, A. D.
Some Methods of Technique applicable to Entomology ... ... 165

KING, H. H.
A Note on the Use of Dried Poison Bait against Locusts in the Sudan ... ... ... ... ... ... ... ... 99

KRISHNA AYYAR, P. N.
A new Pest of Rice in South India (*illustrated*) ... ... ... 173

LAING, F.
Report on Australian Coccidae (*illustrated*) ... ... ... ... 15

MAHDIHASSAN, S.
The first Stage Larva of Lac Insects (*illustrated*) ... ... ... 241

MARSHALL, G. A. K.
New Curculionidae (Col.) from Cacao and Camphor (*illustrated*) ... 201

MARSHALL, J. F., & STALEY, J.
The Graphical Representation of Instar Records in a Regional Mosquito Survey ... ... ... ... ... ... ... 195

MAULIK, S.
New injurious Hispinae (*illustrated*) ... ... ... ... ... 81
Injurious Hispinae from the Solomon Islands (*illustrated*) ... 233

MUIR, F.
A new Species of *Oliarus* (Hom., Cixiid.) on Coconut Palms (*illustrated*) ... ... ... ... ... ... ... ... 409

MUNRO, H. K.
New Trypetidae from South Africa (Dipt.) (*illustrated*) ... ... 391

MYERS, J. G.
Notes on some Natural Enemies of *Plodia interpunctella* and *Silvanus surinamensis* in Australia... ... ... ... ... 425

PAINE, R. W., & EDWARDS, F. W.
Mosquitos from the Solomon Islands (*illustrated*) ... ... ... 303

SALT, G.
*Castniomera humboldti* (Boisduval), a Pest of Bananas (*illustrated*) 187

SAREL-WHITFIELD, F. G.
The Sudan Millet Bug, *Agonoscelis versicolor*, F. (*illustrated*) ... 209

SCOTT, H.
Note on the Life-history of the Fig-tree Moth, *Ocnerogyia amanda*, Staud. (Lymantriidae) ... ... ... ... ... ... 39

SMITH, H. S.
Multiple Parasitism: Its Relation to the Biological Control of Insect Pests ... ... ... ... ... ... ... ... 141

TAYLOR, F. H.
Notes on Australian Culicidae (Dipt.) (*illustrated*) ... ... ... 271

THOMPSON, W. R.
On the Part played by Parasites in the Control of Insects living in protected Situations ... ... ... ... ... ... 457

TRÄGÅRDH, I.
Methods of investigating the Fauna of Tree-stumps (*illustrated*) ... 245

TURNER, R. E.
A new Species of *Microstigmus* (Hym., Sphegid.) (*illustrated*) ... 407

UVAROV, B. P., & ZOLOTAREVSKY, B. N.
Phases of Locusts and their Interrelations ... ... ... ... 261

WIGGLESWORTH, V. B. PAGE
The early Stages of some West African Mosquitos (*illustrated*) ... 59
Observations on the " Furau " (Cicindelidae) of Northern Nigeria (*illustrated*) ... ... ... ... ... ... ... ... 403
WILKINSON, D. S.
New parasitic Hymenoptera and Notes on other Species (*illustrated*) 103
New Species and Host Records of Braconidae (*illustrated*)... ... 205
Seven new Species of Braconidae (*illustrated*) ... ... ... 443
WOLCOTT, G. N.
The Status of Economic Entomology in Peru ... ... ... 225

---

MISCELLANEOUS.

Collections received ... ... ... ... ... ... 115, 251, 463

---

ERRATA.

Page 24, line 6, for " *leucodendron* " read " *leucadendron* "
,, 33, 2 lines from end, for " Froggat " read " Froggatt "
,, 74, legend to fig. 3, for " *Hoplanrothrips* " read " *Hoplandrothrips* "
,, 107, line 6, for " S. F. Light " read " S. S. Light "
,, 174, line 8, for " *urida* " read " *lurida* "
,, 217, legend to fig. 10, for " 3 mm." read " 1·25 mm."
legend to fig. 11, for " 6 mm." read " 2 mm."
,, 218, legend to fig. 12, for " 11 mm." read " 5 mm."
legend to fig. 13, for " 14 mm." read " 8 mm."
,, 219, legend to fig. 14, for " 16 mm." read " 10 mm."
,, 220, legend to fig. 15, for " 22 mm." read " 12 mm."
Plate XII, facing p. 278, for " *metalica* " read " *metallica* "
Page 283, line 23, for " West." read " Waterst."
,, 399, line 17, for " E. G. Bryant " read " G. E. Bryant "
,, 425, lines 20 & 21, for " Schultze " read " Schulze "
,, 436, line 32, for " *Cucumeris* " read " *Cucumis* "

IMPERIAL BUREAU OF ENTOMOLOGY.

# BULLETIN
OF
# ENTOMOLOGICAL RESEARCH.

VOL. XX. 1929.

## A NEW TSETSE-FLY OF THE *GLOSSINA PALPALIS* GROUP OCCURRING IN BELGIAN CONGO.

By Major E. E. AUSTEN, D.S.O.

In the autumn of 1928 Dr. J. Schwetz forwarded to the writer, from Stanleyville, a small collection of blood-sucking Diptera, the majority of which had been obtained by him in the region of the Lower Lomami River. The material sent included specimens of four species of *Glossina*, the determination of three of which (*G. palpalis*, Rob.-Desv., *G. fusca*, Walk., and *G. tabaniformis*, Westw.) presented no difficulty. The fourth species, however, which had evidently attracted the special attention of the sender, since specimens of it were received labelled " ? *G. pallicera*," proves to be new and is accordingly described below. Dr. Schwetz, who is already well known by reason of entomological investigations in Belgian Congo extending over a long series of years, is to be congratulated upon a discovery which brings the number of recognised species of *Glossina* up to twenty.

The new species may be characterized as follows :—

**Glossina newsteadi,** sp. n. (figs. 1 to 5).

♂♀. Length, ♂ (three specimens) 7·6 to 8·6 mm., ♀ (six specimens) 8 to 9·8 mm.; width of head, ♂ 2·6 to 2·8 mm., ♀ 2·5 to 2·75 mm.; width of front at vertex, ♂ 0·5 mm., ♀ 0·8 mm.; length of wing, ♂ 8·6 to 9 mm., ♀ 9 to 9·5 mm.

*A member of the* Glossina palpalis Group, *and in size, colouration and general appearance, apart from the shape of the median pale mark on the second abdominal tergite* (*cf.* fig. 3), *superficially closely resembling* G. caliginea, *Austen, but distinguishable at once by the characters presented by the third antennal segment* (*cf.* fig. 1, a), *as well as by the marking of the second abdominal segment already mentioned; closely allied to* G. pallicera, *Big., but on the whole, at least in the case of the* ♀, *distinctly larger, and moreover distinguishable by the third segment of the antennae being much darker* (*deep mouse-grey* or dark mouse-grey*) *at the tip or even on more than the distal half, while the fringe of pale hair on the anterior and posterior margins, although conspicuous* (when the head is viewed in profile under a hand-lens magnifying 15 diameters—nominal) *and much longer than the corresponding fringe in* G. palpalis, *Rob.-Desv., and* G. caliginea, *Austen, is nevertheless only about three-fifths as long as the same*

* For names and illustrations of colours mentioned in the present paper see Ridgway, " Color Standards and Color Nomenclature " (Washington, D.C. Published by the Author, 1912).

(3005) Wt P5/3521 1,100 5/29 H & Sp Gp 52

*fringe in* G. pallicera (*cf.* fig. 1 a and fig. 2) ; *distinguishable also in the male sex from* G. pallicera, *Big.*, inter alia *by the superior claspers being conspicuously broader, while the narrow portion of the inferior claspers is longer* (*cf.* figs. 4 and 5).

General colouration : dorsum of thorax clove-brown, dorsum of abdomen blackish brown.

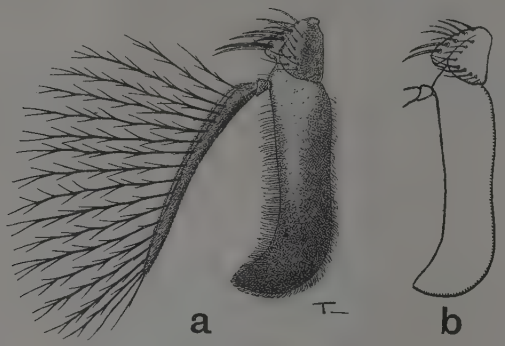



Fig. 1. *Glossina newsteadi*, sp. n. : *a*, antenna of ♀ ; *b*, outline of antenna of ♂ (to show greater prominence of tip of 3rd segment in ♀ ; fringe on 3rd segment, and greater part of arista omitted). ×30.

*Head :* face and jowls in both sexes light buff pollinose, parafrontals darker ; frontal stripe russet anteriorly, dark brown or clove-brown above ; occiput smoke-grey ; *antennae* (*cf.* fig 1*a*) with third segment more or less distinctly and more or less extensively cinnamon-buff at base, cinnamon-buff area sometimes including as much as proximal two-thirds ; but generally distal two-thirds of third segment,

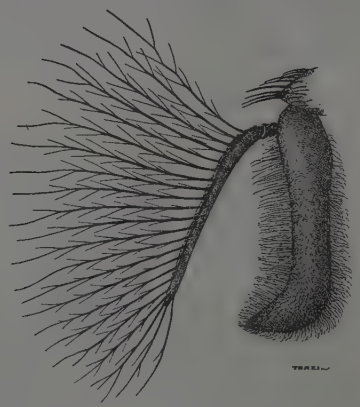


Fig. 2. *Glossina pallicera*, Bigot : antenna of ♀, ×30.

sometimes more, sometimes less, infuscated as described in diagnosis above, anterior margin of segment sometimes infuscated from base to tip ; distal extremity of third segment with its anterior angle more or less prominent ; *arista* long, slender and tapering (much more so than in *G. palpalis*, Rob.-Desv.), bearing from about twenty (in the ♀) to (in the ♂) twenty-one to twenty-three branched hairs.

Fig. 3. *Glossina newsteadi*, abdomen of ♀, dorsal view, ×12, showing the characteristic shape (the same in both sexes) of the pale, median, scutiform mark on the 2nd tergite.

*Thorax:* usual markings on dorsum fairly conspicuous; apical scutellar bristles in ♀ short.

*Abdomen* (*cf.* fig. 3): dorsum with first segment, and basal angles and lateral margins of second segment, as well as a sharply defined and conspicuous, median,

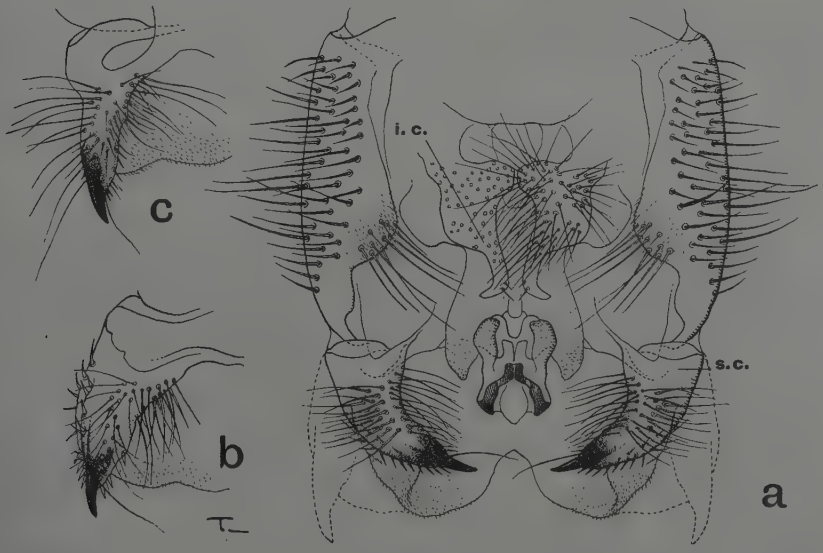



Fig. 4. *Glossina newsteadi*: *a*, genital armature of ♂, ventral view (position of superior claspers and connecting membrane, when former are fully divaricated, indicated by dotted lines)—s.c., superior clasper, i.c., inferior clasper; *b*, right superior clasper as seen when superior claspers are fully divaricated.

*G. pallicera*, Bigot: *c*, right superior clasper, for comparison.

scutiform mark on latter (shaped as shown in fig. 3 and not reaching hind margin), light ochraceous-buff; second to sixth tergites inclusive, with exception of lateral margins and posterior angles, sometimes uniformly blackish brown, sometimes in case of each segment with a blackish brown transverse band, interrupted in middle by an ochraceous-tawny interval of regularly decreasing width; seventh tergite (sometimes, at any rate in ♀, with exception of two blackish brown marks at extreme base), and lateral extremities and posterior angles of third to sixth tergites inclusive deep olive-buff; *hypopygium* of ♂ ochraceous-tawny or isabella-coloured; *superior claspers* of ♂ (fig. 4, *a* and *b*) short and relatively broad—shorter and broader than in *G. pallicera*, Big.; *inferior claspers* of ♂ (fig. 4 *a* i.c.; fig. 5*a*) with narrow distal portion (except actual extremity, which is strongly hook-like) longer and straighter than in *G. pallicera*.

*Wings* dark, strongly and uniformly tinged with fuscous. *Squamae* pale olive-buff, margins pinkish buff, fringed with glistening Naples-yellow hair.

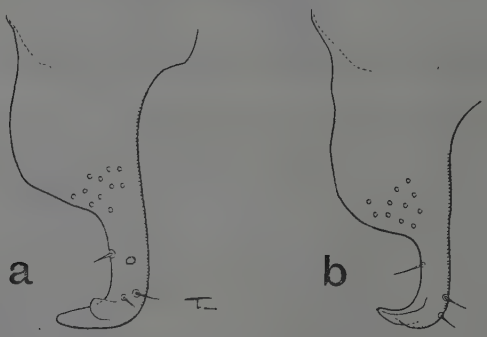



Fig. 5. Right inferior clasper of: *a*, *Glossina newsteadi*; *b*, *G. pallicera*, Bigot (positions of only a few hairs indicated in each case).

*Halteres* cream-buff.

*Legs:* coxae smoke-grey pollinose; femora and tibiae cinnamon-buff, more or less conspicuously streaked or blotched on outer side with deep mouse-grey or dark mouse-grey, especially in case of middle and hind legs; front and middle tarsi ochraceous-buff, tips of last two segments clove-brown or mummy-brown; hind tarsi, except sometimes extreme base of second, and extreme base and tip of third segment, which may be ochraceous-buff, entirely blackish-brown above.

Belgian Congo (Lower Lomami region): type of ♂, type of ♀, two ♂ and two ♀ paratypes, R. Lobayi, vi. 1928 (*Dr. J. Schwetz*); one ♀ paratype, between Elipa and Lukumbe, 5.vi.1928; two ♀ paratypes, R. Elipa, 12.vi.1928 (*Dr. J. Schwetz*).

All the foregoing are in the British Museum (Natural History). The specimens from the R. Lobayi were found in company with *G. palpalis*, Rob.-Desv., which, to judge from the respective numbers of the two species sent home, was enormously in the majority.

It only remains to add that the interesting new species described above has been named in honour of Robert Newstead, F.R.S., *emeritus* Dutton Memorial Professor of Entomology, Liverpool School of Tropical Medicine, in token of personal regard and sincere appreciation of his eminent services to entomology generally, and in particular to the study of *Glossina*.

# THE BIONOMICS OF *LEMA MELANOPA*, L. (CRIOCERINAE), IN GREAT BRITAIN.

By W. E. H. Hodson, A.R.C.S.,

*Department of Plant Pathology, Seale-Hayne Agricultural College, Newton Abbot, Devon.*

(Plates I & II.)

## Introduction.

*Lema melanopa* has for many years been a serious pest of cereal crops in certain regions of Europe, and a very considerable volume of literature has accumulated concerning the life-history of the beetle and suitable means of checking its ravages. Damage is caused by both adults and larvae. The former bite longitudinal strips through, and the latter skeletonise, the leaves. Vassiliev[13] states that, in Russia, the loss resulting from attacks may sometimes amount to from 25 to 50 per cent. of the total crop.

Of late years the insect has been recorded with increasing frequency on grain crops in Britain. No attempt has previously been made to ascertain the extent of the damage occasioned, or to investigate the life-history of the beetle under conditions pertaining to this country. A perusal of the literature, which is principally Russian and Hungarian, suggests that the life-history varies with the locality, and it has therefore been followed in detail. Field observations of the beetle were made during the years 1924 to 1928 and breeding experiments were conducted in 1927 and 1928.

No extensive experiments for the purpose of controlling the beetle have been made at present. It is proposed to undertake these later, and in the meantime those methods more usually adopted on the Continent are to be briefly discussed. Two larval parasites have been found. Reference to these is made below and they will be studied in detail as material becomes available.

## Economic History.

A brief survey of the principal literature will serve to give some indication as to the areas in which the beetle is a pest of standing. It will further show the extent to which the life-history is subject to variation.

Hungary, where oat and barley are the principal crops attacked, appears to be the first country in which serious and extensive damage was recorded. Kadocsa[8] states that serious damage has occurred since 1831 and in 1891 amounted to between £1,000,000 and £1,250,000. Normally the insects appear at the beginning of April, and there is only one generation annually. Infestations go in cycles and usually die away, probably as the result of attack by natural enemies of the beetle.

In Russia, summer-sown oat, barley and wheat are usually damaged, more rarely winter corn and maize. Hemp is sometimes attacked (Kulagin[8]), and also melons, sunflowers, and some vegetables (Uvarov[12]). Vassiliev[13] records that the eggs are laid in April on summer crops, grasses, etc. The larvae pupate in the beginning or middle of June, two to three inches below soil-level, become adult in about 14 days, but do not emerge until the spring. There is only one generation. As opposed to this, Averin[1] records the eggs of the second generation as being heavily parasitised. Vereshtchagin[14] says that in Bessarabia the adults winter in the soil, emerging in April and feeding; eggs are laid on the leaves and the larvae feed for about one month.

More recently, a detailed account of the life-history in Russia is given by Megalov.[11] Eggs are laid on the leaves and hatch in 12–13 days. Larvae feed for

12–13 days and remain as pupae for 14–15 days. Hibernation occurs in the adult stage. The egg-laying period is somewhat protracted and larvae occur for 4–6 weeks. It will be shown later that this approximates more closely to the life-history as observed in Britain.

In a subsequent account Megalov[9] states that the adults appear late in June, feed little, if at all, and hibernate without egg-laying. Oviposition begins in the following May and continues until 19th July. The beetles live a very long time and some may live over the second winter and oviposit again in the second summer. The author does not agree that there are two generations and mentions that an unidentified parasite pupates in the cocoon.

Feytaud[2] remarks that in France the life-history differs from that in Russia. Adults emerge from the cocoons in June and July and may produce a second generation.

In Germany, Hänsel[4] shows that *Lema cyanella*, L., is the more serious species and differs from *L. melanopa* materially, in that the larvae pupate on the leaves. Hänsel further states that the pupal case is constructed of a secretion from glands situated in the head, which seems to be of doubtful accuracy.

A strange record comes from Japan, by Murata & Ikeda.[10] *L. melanopa* is reported as damaging rice. The adults feed at the end of May and oviposit in June, after mating. More than a hundred eggs are laid in several masses, and the larvae pupate on the leaves 2–3 weeks after hatching. As all European records indicate that the eggs are laid singly, and that the larvae invariably pupate in the soil, it would appear that the beetle has been wrongly identified. The species referred to may be *Lema tristis*, Herbst.

Other countries in which the beetle is a pest of note are Bulgaria, Morocco, Turkestan, Sweden and Switzerland.

In Great Britain, *Lema melanopa* first appears to have attracted notice in 1917, when it was recorded from Salop and Kent on oat and barley. In 1923 official reference is made to the beetle and a list of counties from which it had been recorded up to 1921 is given.[5] Walton[15] records it as being widely distributed in North Wales, but usually occurring in small numbers, and Jenkins[6] records it on oat in Mid Wales, where it was particularly prevalent in 1923. Gibson has noted larvae on cereals in the Isles of Scilly. The writer has observed adults and larvae in numbers throughout Devon and Cornwall, from 1924 to 1928, on cereals and grasses; on wheat in Hertfordshire in 1924; and on oat in Northumberland in 1928.

In 1925 several farmers in East Devon called the attention of the writer to larvae of the beetle, which were causing appreciable injury to localised areas of growing barley. Each year subsequently the damage has become more marked, until now, eleven years after damage was first officially recorded in this country, it would be difficult to find a single corn-field, at least in South-West England, from which the beetle is entirely absent.

It must not be assumed from the foregoing that the beetle has become a major pest in Britain. At the same time, if the present rate of increase is maintained, it will have become of considerable significance in corn-growing areas in the course of a very few years.

## Description of the Stages.

*Adult* (Pl. i, fig. 3).

Fowler[3] describes the adult in detail, and it will serve no useful purpose to repeat his description here. It may, however, be recorded that the writer has found the males usually slightly smaller and narrower than the females.

*Egg* (Pl. ii, fig. 2).

Cylindrical, rounded at ends, shining yellow and covered with a glutinous secretion which hardens on contact with the air. Colour darkening almost to black prior to hatching. Length, 1 mm.

*Larva* (Pl. i, fig. 1).

Eruciform; head, spiracles and legs somewhat heavily chitinised, dark brown to black; remainder soft, more or less wrinkled, dirty to bright yellow, bearing numbers of stiff curved hairs, which in the dorsal regions point forwards and on the sides upwards; nine pairs of spiracles; anus situated dorsally and directed forwards; colour in life usually obscured by covering of excrement. Length of full-grown larva, 5–6 mm.

*Pupa.*

Typically Chrysomelid, enveloped in a thin transparent membrane, bright yellow, darkening rapidly until normal adult colouring is attained. Length, 4–4·5 mm.

**Habits of Adult.**

The adult beetles are diurnally active and fly freely at a temperature of 62° F. and over. They are able to alight with a considerable degree of precision on plants, even when these are swaying in the wind. On being alarmed, the beetles fall to the ground, feign death for a few seconds, and then run rapidly for shelter, emitting meanwhile small, but distinct, stridulating sounds.

The adult life is a long one. Some individuals certainly live over a second winter. Males have been observed to copulate in their second spring, but it is debatable as to whether females oviposit again during their second season.

The period of maximum emergence is from the middle of July to the middle of August. Very few emerge earlier, but belated emergences are fairly frequent up to about the middle of September. The whole period of emergence is somewhat later than that usually recorded on the Continent.

Contrary to the experience of Megalov[9] in Russia, it was found that extensive feeding by the adults occurs immediately subsequent to emergence. Emergence coincides very roughly with harvest time, and while the earliest beetles find some nutriment in belated barley and dredge corn fields, the majority feed on such tillers as shoot from the stubbles in wet weather. They migrate thence to the hedges, where they continue to feed freely, principally on cocksfoot (*Dactylis glomerata*), until the end of September. Feeding is effected by gnawing out longitudinal strips from the leaves, not by skeletonising as the larvae do. The resultant damage is almost indistinguishable from that caused by small slugs.

The beetles are late in taking up winter quarters and may be swept from rank herbage up to the end of October. Winter is passed under rubbish, in stacks, in crevices in banks, beneath dead bark, etc., but rarely actually below the soil. Fryer informs the writer that he has taken the beetles in quantities in flood refuse, and the writer once found numbers congregated in discarded sacking in a stubble field.

The beetles usually reappear in April, when numerous individuals may be taken sunning themselves in hedge bottoms. Feeding again commences and at this season is confined almost entirely to young corn shoots around the headlands. Mating commences on warm days towards the end of May.

*Lema melanopa*, in common with some other CRIOCERIDAE, shows at all times a tendency to gregariousness. During the summer and winter the presence of one usually indicates the proximity of several others. This character is most marked during May, when the beetles assemble in groups for the purpose of mating.

Copulation is usually effected on a corn or grass stem, the male being carried for periods varying from a few minutes to over an hour. It would seem that one union is sufficient, for females isolated immediately after copulating have continued to lay fertile eggs for a number of weeks. Further, copulation has never been observed to occur late in the season.

It may be stated here that careful watch has been kept for signs of mating in the autumn following emergence. Freshly emerged males were, in captivity, sometimes observed to attempt union with young females. These attempts invariably occurred during particularly hot weather in August, but in no cases was union seen to be effected and the females were invariably most unwilling.

**Oviposition.**

Oviposition commences about one week after mating has taken place. The eggs are laid singly, each on a carefully selected site. The leaf chosen is usually one about half-way up the plant. The egg is deposited on, or near, the mid-rib, on the upper and inner side of the leaf, about 1 centimetre from the leaf base. Eggs have very occasionally been found on the lower surface of the leaf. No female was observed to lay more than three eggs within 24 hours, one only being usual. During cool spells egg-laying was suspended entirely for several days at a time. From 12 to 27 were laid by observed females, and it is likely that considerably more, say 50, may usually be laid.

The egg when laid is shining yellow, soft and covered with a glutinous secretion. Exposure to the air rapidly hardens the integument, and the egg then adheres firmly to the leaf. As maturity is reached the colour darkens very considerably, until it becomes nearly black prior to hatching 11 to 13 days after being laid.

The earliest date at which an egg has been found in the field, by the writer, was 30th May 1925, and the latest recorded laying date was 28th July 1928. These dates probably indicate almost the extreme limits of the period during which eggs occur.

**Larval Habits.**

The larva emerges by means of a longitudinal split towards one end of the egg and commences to feed, in close proximity to the remains, almost immediately. Feeding is effected by the removal of longitudinal strips from the leaves, the lower epidermis being left intact and the leaves thus partly skeletonised. Large larvae do sometimes eat entirely through the leaves. The first few feeds are composed of minute strips taken from between the veins, only a few millemetres in length. After feeding for a few days on the first leaf, the larva almost invariably migrates to a leaf higher up the plant. Here it commences to feed near the tip and gradually works towards the base of the leaf. A very good idea of the typical injury caused by larval feeding is afforded by Pl. ii, fig. 1. The larva commonly feeds on the upper and inner surface of the leaf, it being unusual to find one on the lower surface.

By a peculiar provision the anus projects forwards and upwards. The excreta, mixed with a milky anal secretion, which acts as a diluting and spreading agent flows forwards over the body. They are retained on this by the curved hairs which cover the dorsal region and sides. The larva remains covered with excreta during the greater part of its active life, only being bare for a short time after each moult and immediately before descending to the soil for pupation. At this latter time the excreta are sloughed off on the leaf, although the skin is not cast.

There are four larval instars. The first occupies usually 4 days, the next two, 3 days each, and the active portion of the final one 4 days, giving a total active larval life of 14 days. Each of the first three instars is terminated by a moult, in which the skin and covering of excreta are sloughed. On becoming fully fed, during the

fourth instar, the excreta only are sloughed. The larva then crawls down the plant and enters the soil, leaving always a small patch of white anal secretion at the actual point of entry. Arrived at a depth of from two to three inches the larva constructs a pupal chamber of anal secretion. Pupation usually takes place about seven days after the larva buries.

**Pupa.**

The pupa is enclosed in a thin membranous envelope and is bright yellow in colour when first formed. The eyes commence to darken usually after 3 days and normally the adult emerges 20 days after the larva buried. The shortest period which was recorded was 17 days and the longest 24 days.

No healthy pupa, collected in the field or obtained from larvae reared in captivity, failed to produce an adult within the period named above. It therefore seems very unlikely that the beetle overwinters in the pupal case in this country.

**Duration of Life-cycle.**

The normal cycle, from egg to adult, is comprised as follows. Length of egg stage 11 to 13 days; larval stage, prior to the formation of the pupal chamber, 13 to 16 days; pupal stage 17 to 26 days. The shortest period recorded for the cycle was 43 days, and the longest 50 days. It may be stated that 90 per cent. of the total number of beetles bred emerged between the 45th and 47th days after the eggs were laid. Beetles emerging before the 46th day were, almost without exception, males.

As mentioned previously, the adults exhibit a considerable degree of longevity. Individuals of both sexes have been successfully brought through two winters. The extreme limit recorded by the writer was the case of a male which lived for 25 months and fed to within two days of death, although minus several tarsi and one antenna for the last six months.

**Number of Generations.**

There is every indication, based on extended observations, that but one generation of the beetle is produced annually in this country. At the same time, climatically, conditions here are more favourable for the occurrence of a second generation than is the case in Central Europe, where the summer, although hot, is relatively short.

The tendency exhibited by young males to copulate before going into hibernation, coupled with the fact that larvae have been induced successfully to mature and to pupate as late as 24th August, producing adults in September, suggests that the production of a second generation might be possible in Britain. Additional evidence in support of this possibility is rendered by the occurrence of eggs in the field over a period of 59 days. The complete cycle from egg to adult occupies only 43 to 50 days. There is, therefore, sufficient time for progeny of the first eggs to have matured in time to lay those found towards the end of July.

**Food-plants.**

Barley, oat and wheat, in the order named, are the favourite larval food-plants in this country. Larvae have been found in the field on Cocksfoot (*Dactylis glomerata*), Timothy (*Phleum pratense*), and Couch (*Agropyron repens*), and have been reared satisfactorily on Canary grass (*Phalaris canariensis*). Adults feed freely on any cereal, particularly in the spring and early summer, but their staple food after harvest is Cocksfoot.

**Parasites.**

It is proposed to give a full account of the parasites of *L. melanopa*, found in Britain, in a subsequent publication. Nevertheless, it may here be recorded that two Hymenopterous parasites have been found, both of which parasitise the larval stage.

The first, a Chalcid belonging to the genus *Tetrastichus*, emerges from the pupal chamber of the host shortly after this is completed. There are at least two generations a year, and probably three. The final one winters in the larval stage in the pupal chamber of the host. Six per cent. of all captured larvae were parasitised by this insect, from three to ten parasites occurring in each host.

The second parasite, at present unidentified, appears to complete but one generation annually, the winter being passed in the same way as by the previous insect. Of all larvae captured 18 per cent. were parasitised by this latter parasite, only one specimen of which occurred in each host.

It is thus seen that no less than 25 per cent. of all the larvae captured in the field were parasitised by one or other of these two insects. Further, the more numerous parasite would appear to have only one generation annually and to have ceased parasitising larvae after the middle of July. In the event of a second generation of the beetle becoming common here, this would very possibly escape altogether the attentions of this parasite.

**Nature and Extent of Injury Caused.**

The injury to crops falls into two groups, namely, that caused by the adults and that caused by the larvae. The adults feed freely during the summer months immediately after emergence, but cause negligible injury at that time. Their attentions are confined almost entirely to nearly mature cereals and to grasses. In the spring the available supply of food is somewhat different and extensive damage can be caused. Feeding then takes place almost exclusively on the tender foliage of growing corn. Longitudinal strips are eaten from the leaves and numbers of these are so badly damaged that they shrivel and die away, the whole plant thereby being severely checked. As mentioned earlier, the feeding marks made by the adults bear a very close resemblance to those of small slugs. In several cases that have come to the notice of the writer damage by the adult beetles has erroneously been attributed to the former pest by the owners of the crops.

The larvae feed generally on the leaves of cereals and in infested fields cause a still further reduction of vigour in plants already checked by the adults. Measurements show that a single larva, in the course of attaining maturity, eats actually approximately six square centimetres of leaf surface. This area is, in itself, not a large one, but as the larval feeding is distributed over several leaves, the actual area damaged is much larger and amounts to about five normal leaves. In other words, each larva, by reducing the foliage, is able to render almost useless, at a minimum, one potential ear of grain. Each female beetle lays at least 20 and probably double that number of eggs. It can, therefore, be seen that quite a moderate infestation will very appreciably reduce the crop of grain and straw.

It has been shown that *Lema melanopa* appears definitely to be on the increase in this country, or at least in the south-western portion of it. At present it is not responsible for such extensive losses as to warrant the use of costly control measures against it. Nevertheless, in view of the serious damage occasioned in other countries, it is very desirable that some effort should be made to check the increase.

**Control Measures on the Continent.**

Observation shows that attacks generally occur in definite patches. These patches, at least in this country, are usually confined to areas adjacent to the edges of the

field and may frequently be reached from the headlands. Vassiliev [13] notes that the patches tend to occur first in wet and low-lying spots in the field. The occurrence of these comparatively heavy local infestations is readily explained by the gregarious habit displayed at the time of mating.

Inspection of the literature reveals a host of different measures suggested as controls. From their diversity and numbers one gathers that no one of them is entirely satisfactory, or suited to all conditions. This is not surprising when taking into consideration the variable life-history, the longevity of the adults, and the protracted period of oviposition. It is proposed briefly to enumerate the more important methods of control adopted on the Continent and later to discuss the possible application of some of them under conditions pertaining to this country.

*Cultural Methods.*

The sowing of winter corn, or, alternatively, the early sowing of spring crops, is recommended in areas prone to severe damage from the pest in Russia. A considerable measure of success appears to attend these methods, owing presumably to the sturdy plants thus obtained being able better to withstand the preliminary attack by the adult beetles. Considerable losses are, nevertheless, sometimes sustained later in the season as a result of the larval feeding.

The ploughing of stubbles immediately after harvest is also frequently practised in Russia. The object of this measure is to bring about the destruction of the pupae in the soil.

Severe local infestations by the larvae are sometimes countered by cutting the damaged portions of the crop. These are immediately carted from the field and used as green fodder for cattle, or, alternatively, dried for subsequent use as bedding. By these means the majority of the larvae are destroyed and there is a reasonable hope of obtaining a subsequent crop, relatively free from attack.

*Collection of Adults.*

The capturing of adults in sweep-nets has been attempted in Hungary, but the practical application of this remedy appears to be strictly limited. It is possible that in the mating season numbers of beetles could be collected by this means. At the same time, if numerous enough to warrant such a measure, a spray, or dust, would probably prove a far more effective method of disposal.

*Spraying.*

For a number of years, in both Russia and Hungary, a spray, containing 4 or 5 per cent. of barium chloride and 4 or 5 per cent. molasses, was almost exclusively the one used against the pest. Molasses were added principally for their adhesive properties. As a spray this was reasonably cheap and quite fairly effective. Nevertheless, more recently several other substances have come into favour.

In Russia, Paris green has come rapidly to the fore in the past few years, until now, Paris green with quick-lime, and sometimes molasses, may be considered to be the standard spray fluid in that country. The usual strength employed is approximately, Paris green 20 lb., quick-lime 4 lb., and water 100 gallons. An identical spray has been used with success in Bessarabia.

A dilute sodium arsenite spray, with lime added, has been found effective against adults in Russia. It is however apparently too expensive to use on an extensive scale against the larvae also.

While in Russia a spray containing as the principal ingredient a metallic salt, has remained the standard method of combating the pest, in Hungary preference is now shown for alkaloid substances. Nicotine sulphate is generally used, and it is

claimed that the results obtained are far superior to those associated with the old barium chloride spray. The standard spray consists of nicotine sulphate 4 lb., soft soap 15 lb., and water 100 gallons.

In France a spray containing nicotine has been used with success, at the rate of 50 to 60 gallons of spray to the acre. In Germany and Russia, solutions of tobacco extract have sometimes been resorted to.

A spray containing 2·5 per cent. pyrethrum extract has proved very effective in Hungary. It is, however, there considered to be too expensive for general use.

*Dusting.*

Dusting does not appear to have ever been seriously adopted against the pest, except in Russia. Even in that country opinions have on the whole, until quite recently, indicated that spraying is a superior means of control.

Earlier records relate to the use of ashes, or a mixture of ashes and lime. These were usually applied early in the day, when the plants were likely to be damp. The covering of excreta carried by the larvae protects them, in a large measure, from the effects of a contact poison, and the benefit derived from the use of such dusts was largely due to the deterrent effect upon feeding and ovipositing adults.

Lime dusts containing small quantities of Paris green have been used. One consisting of cement and sand with 2 per cent. of Paris green added has proved efficient, in one case a 100 per cent. kill of larvae being recorded after using it. At the same time, opinions indicate that spraying would be likely to afford a more satisfactory control in most cases.

The most recent dusting experiments are those made by Megalov.[9] He finds that a dust composed of one part calcium arsenate to from five to ten parts of sifted lime is highly lethal to both adults and larvae. He adds that the dusting should be carried out before most of the eggs are laid, owing to the increasing resistance to poisons shown by the larvae as they approach maturity.

## Possible Control Measures in Britain.

At the time of writing it has not been possible to carry out field-scale experiments with a view to controlling attacks of the pest. A number of experiments are to be undertaken during the next few seasons. In the meantime, an accurate knowledge of the life-history of the beetle in this country has been obtained, and the control methods most generally in use on the Continent have been reviewed. It is therefore possible to remark upon these latter and to discuss the possibility of applying some of them under the conditions found here.

*Cultural Methods.*

Field observations indicate that very little difference can be found here in the intensity of attack present on autumn and early spring-sown corn respectively, but late-sown corn certainly does suffer more damage. For a number of reasons the early sowing of spring corn is frequently practised here, and undoubtedly attention to this point will tend to reduce the damage attributable to the pest.

As shown earlier in this paper, 90 per cent. of the beetles have emerged as adults at the time of harvest. It is therefore clearly useless to attempt to control them by the early ploughing down of stubbles. This practice is widely adopted in Russia, where the period spent in the soil is considerably longer.

The premature cutting of areas badly attacked by the larvae would appear to be a sound and practicable means of reducing the numbers of the pest. Severe infestations are usually, at first, restricted to strips along the sides of the fields, often only 2 yards deep by 5 to 10 yards long, or occur in pockets, perhaps 5 yards square.

Isolated larvae can be found outside the main concentrations, but it is not until later in the season that the infestations become more widespread. The spread of the areas is due to the beetles gradually becoming scattered over the field as the pairing season draws to a close, but provided that the initial infestations are destroyed, a very large proportion of the larvae will be accounted for. It must be borne in mind that the cutting should be done before many of the larvae approach maturity, or they may be able successfully to metamorphose. Furthermore, the cut plants should be dried rapidly, or if this is impossible, removed from the field and preferably fed green to stock. If the plants are allowed to lie damp for several days the larvae will certainly mature.

*Collection of Adults.*

No cases have been observed in which the beetles have been sufficiently numerous to warrant serious steps being taken to collect them.

*Spraying.*

The possibility of wholesale spraying of corn crops in Britain is, from the economic standpoint, not great. Added to this, the exceedingly protracted egg-laying period of the beetle suggests that at least two, probably three, sprayings would be needed in order to effect anything like a satisfactory control.

As opposed to these disadvantages, infestations occur in relatively small areas and, therefore, the spraying of large acreages would very rarely be needed. Further, the adults frequently, and the larvae almost invariably, feed on the upper leaf surfaces, which obviates the necessity for thorough or heavy spraying. A light deposit of poison on the upper leaf surfaces would be almost as efficient as a thorough soaking of the plants. Provided then that a suitable poison is used, much might be done by one man, equipped with a knapsack sprayer, towards reducing attacks of the dimensions normally found at present in this country.

*Dusting.*

Dusting, as a means of reducing insect attacks, has for a variety of reasons, many of which are poor ones, never achieved great popularity here. Dusting is admittedly seldom as efficient as spraying, from the point of view of percentage kills obtained. It is on the other hand usually considerably cheaper and much more rapidly effected. The possibilities of dusting against the pest in question, where two or three repetitions in one season are desirable, appear to be considerable. In view of the results obtained in Russia recently, it is proposed to carry out a number of dusting experiments during next season.

## Summary.

The beetle, *Lema melanopa*, is a serious pest of cereal crops in certain areas of Europe and is becoming increasingly common on cereals in Britain. A survey of the literature indicates that the life-history differs in various localities, and no previous account has been given of the life-history in this country.

The life-cycle in Britain is briefly as follows. The adult beetles emerge from hibernation in April, mate and commence to oviposit towards the end of May. Oviposition continues for nearly two months, and adults commence to emerge early in July and continue to do so until September. There is no indication that a second brood occurs, although the climate would permit of one.

The adults feed freely after emergence, but largely on grasses, prior to hibernating in November. In the spring they feed almost exclusively on the leaves of young cereals. The larvae feed principally on cereals. Adults tend to be gregarious and are very long-lived, numbers living over a second winter.

Two larval parasites occur in Britain and further information concerning these is being obtained. Of all larvae collected in the field 25 per cent. were found to be parasitised.

The loss of crop sustained as a result of attack by this pest amounts on the Continent, in extreme cases, to as much as 50 per cent. of the total. Control measures consist of cultural methods, spraying and dusting. Certain of these might be adapted for use in this country with reasonable hope of success.

*References.*

(1) Averin, V. G. Review of the Pests noticed in the Govt. of Charkov during 1913, pp. 10–65.

(2) Feytaud, J. Un parasite de la miliade, *Lema flavipes*, Suffr.—Rev. Zool. agric. & appl., xxiii, no. 7, Bordeaux, July, 1924, pp. 158–161.

(3) Fowler, Rev. Canon. The Coleoptera of The British Islands, iv, London, 1890, pp. 281–282.

(4) Hänsel, S. Beitrag zur Kenntnis der Biologie des Getreidehähnchens, *Lema cyanella*, L.—Zs. wiss. Insektenbiol., xix, no. 1, Berlin, Jan. 1924, pp. 27–29, 7 figs.

(5) Insect Pests of Crops, 1920–1921.—Min. Agric. Fisheries, Miscell. Publ. no. 39, London, 1923, p. 8.

(6) Jenkins, J. R. W. A Survey of the Insect Pests of Mid & West Wales.—Welsh Jl. Agric., iii, 1927, p. 198.

(7) Kadocsa, G. *Crioceris melanopa*, injurious to Oats and Barley in Hungary.—Kisérletugyi Kötzlemények, xviii, no. 1, Budapest, 1916, pp. 108–176, 8 plates.

(8) Kulagin, N. M. Insects injurious to cultivated Field Plants in European Russia in 1914.—Bull. Soc. Ent. Mosquensis, i, Nov. 1915, Moscow, pp. 136–161.

(9) Megalov, B. *Lema melanopa*, L., a Pest of Oats, Barley and other Graminaceous Plants.—Saratovsk. Oblastn. S. Kn. Opitn. Stantz. Ent. Otd. Saratov, 1927, 29 pp., 2 pls., 46 refs.

(10) Murata, J. & Ikeda, T. *Lema melanopa*, L., in Nagano Prefecture.—Jl. Plant Protect., xiii, no. 1, pp. 9–19, Tokyo, Jan. 1926.

(11) Report on the Work of the Ent. Dept. for 1920–1925.—Saratovsk. Oblastn. S. Kn. Opitn. Stantz. Saratov, 1925, 31 pp.

(12) Uvarov, B. P. Report of the Bureau of Entomology of Stavropol for the year 1912.—St. Petersburg, 1913, 32 pp.

(13) Vassiliev, E. M. The chief Remedies against the Larvae and Beetles of *L. melanopus*, L., a Pest of summer-sown Grain.—Studies from the Experimental Entomological Station of the All-Russian Society of Sugar-refiners for the year 1912, Kiev, 1913, pp. 1–2.

(14) Vereshtchagin, B. Experiments on the Control of *L. melanopa*, L., in Bessarabia.—Agriculture of Bessarabia, Kishinev, no. 19, 1924, 4 pp.

(15) Walton, C. L. The Agricultural Zoology of North Wales.—Dept. Agric., University College of North Wales, Bangor, 1927, p. 18.

Fig. 1. Full-grown larva, × 11.

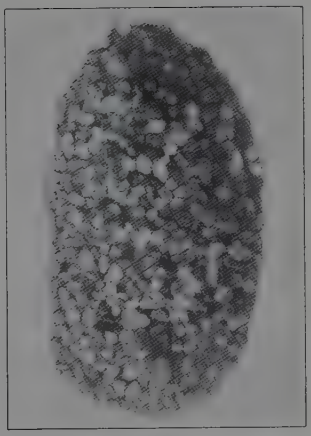


Fig. 2. Pupal case constructed in sand, × 8.

Fig. 3. *Lema melanopa*, L., × 15.

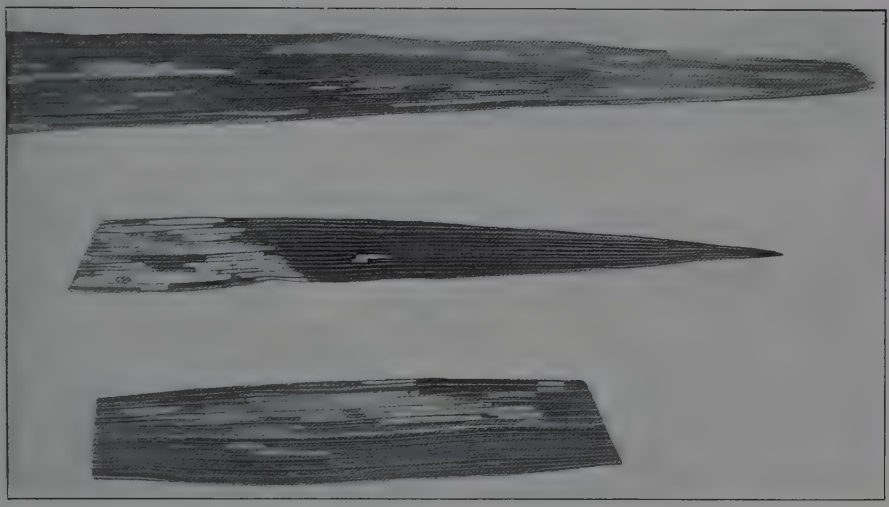


Fig. 1. Oat leaves showing typical injury by larvæ of *Lema melanopa*, L., × 1.5.

Fig. 2. Egg of *L. melanopa*, *in situ* on leaf, × 15.

# REPORT ON AUSTRALIAN COCCIDAE.

By F. Laing, M.A., B.Sc.

## Diaspidinae.

The following report has been drawn up mainly from collections received through the Imperial Bureau of Entomology from Messrs. C. French and G. F. Hill. I have also included some records resulting from an examination of collections made by Dr. F. R. Rodway and Mr. R. Kelly, while E. E. Green, who has always been very ready to render every assistance, very kindly turned over to me for description several species which he had under manuscript names. Figures of previously described species have been added where considered necessary; those given by Maskell are often, it must be confessed, misleading, while those used by Froggatt in his Catalogue are illustrations mainly of the external appearance, and, though excellent in their way, are not altogether satsifactory for the critical determination of species. Leonardi in his Monograph of the genus *Lepidosaphes* was content, where he gave an illustration at all,with one of the pygidial fringe, but there are other characters to be found in the pygidium, and for a full appreciation and understanding of these, this area requires to be figured in entirety. The whole of the Australian Coccid fauna, so distinctive in many respects, requires to be re-examined and fresh descriptions, based on morphological characters, drawn up. Of the numerous genera erected by MacGillivray I have accepted only one in the present paper; as he based his genera on descriptions only, I prefer to express no opinion on the standing of the others he erected until I have examined a more extensive series of species.

**Pinnaspis melaleucae,** sp. n. (fig. 1).

Female puparium of normal chionaspiform shape, straight, not curved, rather markedly dilated behind, often expanded more strongly on one side than the other, the greatest breadth about two-thirds the length, snowy-white, opaque, smooth; exuviae blackish grey, paler around the margins. Length 1·6 mm.

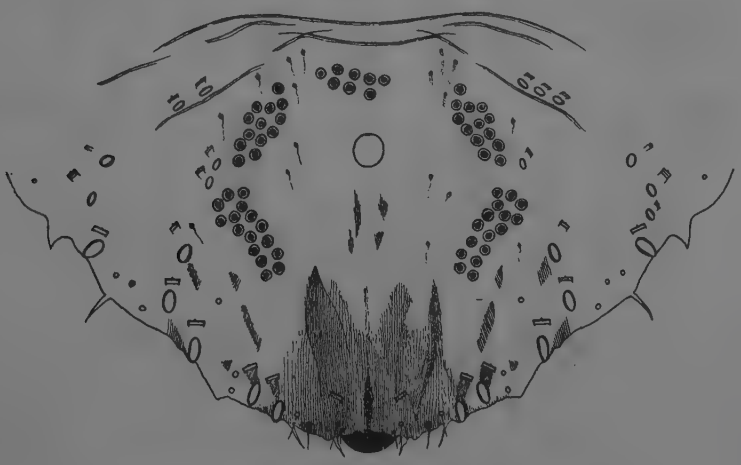


Fig. 1. *Pinnaspis melaleucae*, sp. n.: pygidium of adult ♀.

Male puparium narrow elongate, parallel-sided, tricarinate; pellicle very pale stramineous. Length 1·1 mm.

Adult ♀ clearing completely in caustic potash, oval, if anything narrower in front than behind, length quite twice the breadth; antennal tubercles small and inconspicuous, with a single, slightly curved seta; anterior pair of spiracles with a small group (3–4) of parastigmatic pores, these absent from the posterior pair; minute, slender, short, trichiform setae very sparsely scattered on cephalic region; small tubipores present on the marginal areas of the metathorax and abdominal segments, the former with fewer than the latter, which have also a small number of filiform spinnerets more medianly; one or two spinulae on the margin of the last two prepygidial segments. Pygidium low and broad, with median trullae only present, these somewhat recessed, both completely fused along inner margins, very shallow, the length not half the combined breadth, outer margin broadly and flatly rounded; spiniform squamulae, spines, and marginal gland pores in normal positions; first series of dorsal pores consisting of 1–2 anteriors only, the second series of usually two posteriors and 2–4 anteriors; perivulvar pores in five groups, the formula: 15, 14, 7–8, 15, 13. Length 0·6 mm.

N. Queensland: Townsville, on *Melaleuca leucadendron* (*G. F. Hill*).

The shape of the median lobes, reminding one of *P. minima* (Green), the few dorsal pores, and the colour of the exuviae should serve to distinguish the species. It is one of the species turned over to me for description by Mr. Green, and I have adopted his manuscript name.

**Chionaspis rotundiloba,** sp. n. (fig. 2).

Secretionary appendix of female puparium greyish, but material not available for additional details. Male puparium strongly tricarinate.

Fig. 2. *Chionaspis rotundiloba*, sp. n.: pygidium of adult ♀.

Adult ♀ ovate, anterior end rather narrow, widest across posterior abdominal segments, from twice to thrice as long as broad ; whole body membranous ; antennal tubercles with one very long, stout, curled seta, and one (or two) short, blunt protuberances ; anterior pair of spiracles with a few (3 to 6) parastigmatic pores, the posterior pair without ; a transverse series, interrupted in the middle, of small conical tubercles across the venter of metathorax and a crowded group of similar but rather larger tubercles on the margin of the first abdominal segment ; a few scattered tubercles of similar type on mesothorax ; marginal fistulae and tubipores numerous on the abdominal segments. Pygidium with median trullae large and prominent, broadly rounded, with their free extremities approximately semicircular and oblique thickened bars at base, the inner margins fused basally ; second pair of trullae subobsolete, composed of two lobules, the first slightly larger than the second, but both very weak ; in the first lateral interval is a marginal chitinous incrassation ; marginal pores and fistulae large and conspicuous, the fistulae arranged 2, 2, 3, 4 ; a seta immediately beyond median trullae and another strong one before each of the first three lateral groups of fistulae ; perivulvar pores in five groups with the formula 18, 21, 6, 20, 20, but the totals of each vary considerably, the highest formula observed being 37, 28, 4, 22, 23 ; first series of dorsal gland pores absent, second series with 4–5 posteriors and a similar number of anteriors, the next lateral series with 3 and 7. Length, 0·8 mm. to 1·7 mm. ; the breadth in the smaller specimens is about half the length, in the larger about one-third.

N. Queensland : on *Eucalyptus* (*G. F. Hill*).

I have adopted the MS. name given by Mr. Green. The very conspicuous median trullae together with the practical disappearance of the lateral pairs serve to make the species easy of recognition.

**Phenacaspis formosa,** Green, (fig. 3).

Victoria : Goulbourn River, on *Eucalyptus rostrata* (*C. French*).

Green, in his description, states that the median lobes only are present, but in my series, and in specimens I have received from Froggatt, the duplex second trulla is also present, though small ; otherwise there are no distinctions, and as a preparation showing the second trulla is somewhat difficult to obtain, it is hardly necessary to regard this particular material as representing a variety. The great development of the median trulla and the numerous orifices of the first series of dorsal glands are every distinctive. The species has been omitted from Froggatt's Catalogue of Australian Coccidae.

**Poliaspis syringae,** sp. n. (fig. 4).

Female puparium snowy white, smooth, shining, of typical shape, broad in front, tapering behind ; exuviae pale brownish yellow, occasionally with a faint orange tint, terminal.

Male puparium snow white, the surface presenting a somewhat woolly appearance, more or less parallel-sided, or slightly broader in front and tapering gently posteriorly, non-carinated ; exuviae very pale yellowish brown.

Adult ♀ clearing completely in caustic potash, broadly ovate, the breadth about five-eighths the length ; antennal tubercles with a single, stout, curved seta ; a few parastigmatic pores to each pair of spiracles ; a few minute submarginal setae on cephalothoracic region ; marginal pores present, a few on the prothorax, more numerous on the segments from the mesothorax backwards, becoming on the abdominal free segments a lateral and submedian series ; squamiform spines present on marginal area of abdominal segments, and a few, more dorsally, on the thoracic segments. Pygidium with the median pair of lobes only well developed, large, broad, flat, nearly twice as broad as long, divergent, very minutely serrated ; the

Fig. 3. *Phenacaspis formosa* (Green) : pygidium of adult ♀.

second pair of lobes more or less rudimentary, bilobulate, the inner lobule the more strongly developed, the outer subobsolete ; a pair of triangular gland prominences in the third position ; a pair of minute setae in the median interval, a spiniform squama in the first and second lateral intervals, and spines in the usual positions ;

Fig. 4. *Poliaspis syringae*, sp. n. : pygidium of adult ♀.

dorsal pore series represented by four anteriors in the first arch, 7–8 posteriors and 7–9 anteriors in the second; perivulvar pores consisting of a posterior series of five groups according to the formula 26, 14, 3–4, 15, 25, and an anterior series of three groups with a formula 3, 3, 4. Length, 0·9 mm.; breadth, 0·6 mm.

VICTORIA: Kew, on lilac (*C. Plumridge*).

Most closely related to *P. media*, Mask., described from New Zealand, but the median pair of lobes are larger and rather more protruding. For further distinctions the figure given here may be compared with that of *P. media* by Morrison (Proc. U.S. Nat. Mus. lx, art. 12, p. 87, 1922).

**Poliaspis callitris,** sp. n. (fig. 5).

Adult ♀ of the normal *Chionaspis* shape, snowy white in colour with the exuviae very pale stramineous. Length, 2·2 mm.

Adult ♀ clearing completely in caustic potash, of the normal shape of the genus, rather narrow in front, broadening out gradually to penultimate free abdominal segment, thereafter contracting slightly to the rather flat pygidium. Antennal

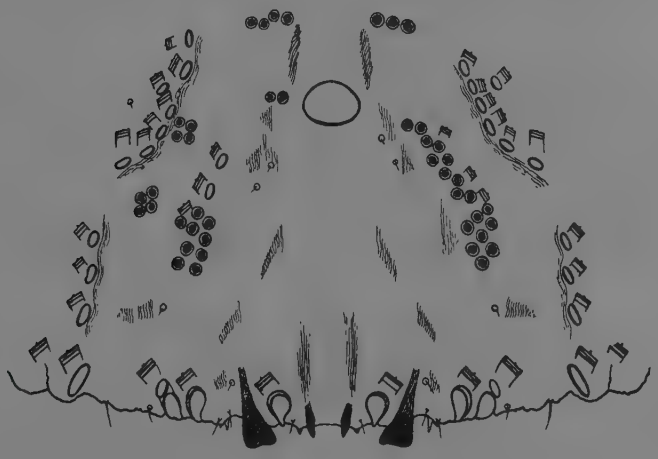


Fig. 5. *Poliaspis callitris*, sp. n.: pygidium of adult ♀.

tubercles small with a single fairly stout seta. Spiracles without any parastigmatic pores. Tubular pores present on the margin from about midway between the anterior and posterior spiracles to the last free abdominal segment; only on the last two prepygidial segments do these pores show signs of dividing into two series, a marginal and sublateral. Pygidium rather broad and flat, the median pair of lobes small, almost rudimentary, triangular, separated by an interval about equal to that of a single lobe; second pair of lobes more normally developed, subtriangular in shape, narrow at the base, broadening out to a distinctly truncate apex; no other lobes; marginal gland orifices in the usual positions, prominent, one between the first and second pairs of lobes, and two beyond the second; spines and gland spines weakly developed; dorsal glands consisting of 2–3 anteriors in the first series, and the second series of 3–4 posteriors and 6–7 anteriors. Perivulvar pores with a posterior series in the normal positions consisting of five groups according to the formula 9, 8, 2, 8, 8;

an anterior series of two submedian groups of 3–4 each, and sometimes another group of 4–5 lying laterad of the anterior and posterior inner groups. Length, 1·1 mm. ; breadth, 0·46 mm.

VICTORIA : Mallee, on *Callitris* (*J. E. Dixon*).

It is with very considerable hesitation that I have described this as a new species. The pygidial characters are almost identical with those of *Chionaspis striata*, Newst., but the additional number of groups of perivulvar pores takes this species on *Callitris* out of the genus *Chionaspis* and places it in *Poliaspis*. It is not merely a question of one or two specimens showing this peculiarity but an extensive series, while an examination of a corresponding series of *Chionaspis striata* has failed to reveal any tendency towards the development of additional groups of pores. It may be that the introduction of *C. striata* into Australia has caused the species to vary in this direction, but until more definite evidence is forthcoming, it is better, I think, to keep it distinct.

**Poliaspis lanigera,** sp. n. (fig. 6).

Female puparia densely massed together on the lower surface of the leaf, entirely covered with a thick, snowy-white, woolly-looking secretion, rough and irregular

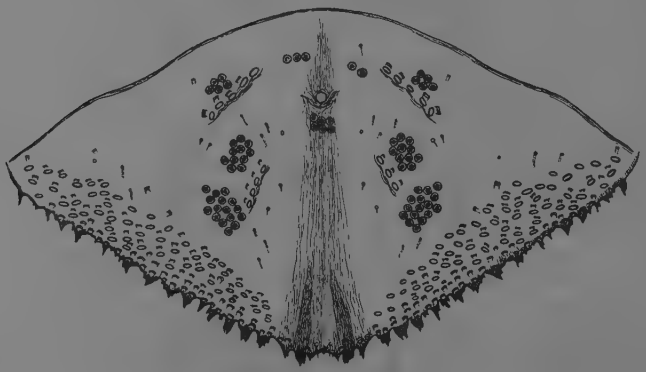


Fig. 6. *Poliaspis lanigera*, sp. n. : pygidium of adult ♀.

in texture ; when disinterred from the mass, the puparium short, broadly mytiliform, the actual covering shield, with the secretion removed, very thin, white, and tissue-paper-like ; exuviae very pale brownish yellow, entirely concealed by the white secretion, the larval, and perhaps also the nymphal, pellicle with long, thin, white dorsal threads curling above the general secretionary matter. Length, 1·7 mm.

Male puparium very similar in texture to that of female, slightly wider behind than in front, non-carinated, the pellicle exposed, free from secretion, pale brownish yellow. Length, 1 mm.

Adult ♀ dark brown to almost black, clearing completely in caustic potash ; cuticle soft, membranous ; broadly oval, the breadth about three-fifths the length ; each antennal tubercle with one long, slightly curved, stout seta, and a shorter and more slender one ; both pairs of spiracles with a few parastigmatic pores, the anterior pair with usually from 3 to 6, the posterior with 1 to 3 ; very short, slender setae sparsely present sublaterally on cephalic region ; pores present laterally on the segments from the mesothorax backwards, but a few, though not conspicuous, on

cephalic area; short, sharp, stout tubercles also present, proximal, and posterior, to anterior spiracles, becoming marginal on abdominal segments. Pygidium with median trullae widely separated, rather irregular in shape, usually with the sides approximating apically, truncate with one or more points, the interval between the two equal to thrice the breadth of one trulla, and containing two small subconical projections and a pair of setae; the whole of the lateral margin with projections, varying in shape and number, as to shape usually triangular with the margin broken by sharp points, the more median sometimes truncate, as to number from 10 to 15; perivulvar pores in two concentric series, the inner of five groups with the formula 17, 9, 5, 11, 14, and the outer of three groups, with the formula 5, 3, 5, occasionally the middle group subdivided; dorsal pores exceedingly numerous, forming several tiers right along the margin of the lateral area, and a first arch with usually 4, and a second of 5–6 anteriors. Length, 1 mm.

NORTHERN TERRITORY: Darwin, on leaves of ? mangrove (*G. F. Hill*).

This species is unique in its pygidial characters—the multilobate nature of the lateral margin, and the many rows of dorsal pores on the lateral area and running parallel with the margin. It is obvious that it has little in common with the genotype of *Poliaspis*, but I prefer to leave it here pending a re-classification of this and allied genera.

**Poliaspis exocarpi,** Mask.

VICTORIA: Ringwood, on *Daviesia latifolia*; Sandringham, on *Exocarpus cupressiformis* (*C. French*); Millgrove, on *D. corymbosa* (*J. E. Dixon*).

I have assigned the material from these host-plants to *P. exocarpi* because of the unsatisfactory characters that would otherwise separate it off. The number of the pores in each perivulvar group, and the number in the series of dorsal pores vary, both in specimens from *Exocarpus* itself and from *Daviesia* spp. Though I have not had an opportunity to study typical material of *P. nitens*, Fuller, found on the same host genus in Western Australia, from the description that species would seem to be distinct.

**Aspidiotus gidgei,** Frogg. (fig. 7).

VICTORIA: on the Murray River, near Hattah, on *Acacia stenophylla* (*J. E. Dixon*).

I have assigned these specimens to *A. gidgei*, Frogg., purely on the strength of the description, as Mr. Froggatt has been unable to supply me with any authentic material for comparison. As Froggatt's description deals almost entirely with external characters, the accompanying figure of the pygidium may make determination easier.

**Aspidiotus loranthi,** sp. n. (fig. 8).

Puparium of adult ♀ subcircular, highly convex, almost conical, dark blackish grey, practically the colour of the bark of the host-plant, the surface roughened and corrugated; pellicles subcentral bright orange-yellow; a subcircular white patch left on bark when scale removed. Diameter 0·75 mm,

Adult ♀ very broadly obovate, the greatest breadth (across by the anterior pair of spiracles) about seven-eighths the length, tapering rather abruptly to the apex of the pygidium; clearing completely in caustic potash. Antennal tubercles with a single stoutish seta; no parastigmatic pores; cephalothorax free from setae, the free abdominal segments with one or two slender marginal ones. Pygidium broad and short, with a single pair of median trullae only, with parallel entire inner margins, rounded apices, and deeply notched externally; in the position normally of the second pair of lobes is a strong spine and a spinose squama, and of the third pair, two spines; the second and third intervals with deep incrassations, comparable actually

to paraphyses, the first pair clearly separate with two pores lying between them, the second pair also distinct but with their bases more closely together ; no perivulvar pores ; two pairs of basal calli, a submedian, and a sublateral pair ; dorsal glands few

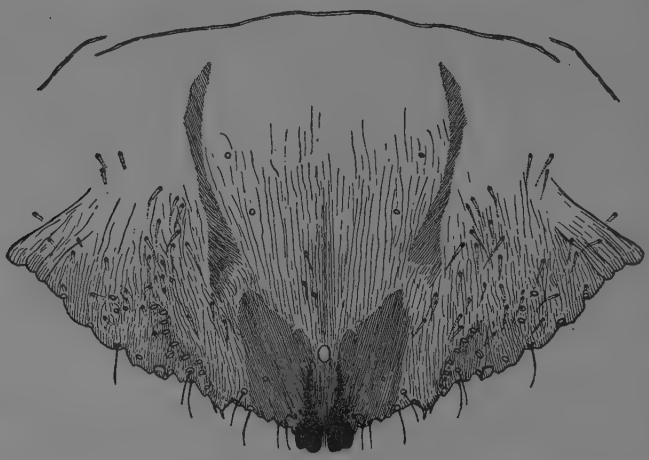


Fig. 7. *Aspidiotus gidgei*, Frogg. : pygidium of adult ♀.

and confined to two submarginal series of about five each ; filiform spinnerets few. Length, 0·9 mm. ; breadth, 0·8 mm.

Victoria : Eltham, on *Loranthus pendulus* (*J. E. Dixon*).

Fig. 8. *Aspidiotus loranthi*, sp. n. : pygidium of adult ♀.

In spite of the somwhat different type of incrassation on the margin of the pygidium, I should place this species in the genus *Hemiberlesia*, and as belonging to the *camelliae* group,

**Aspidiotus hederae,** Vall.

VICTORIA : Ringwood, on *Acacia myrtifolia* ; Melbourne, on *Aspidistra* (*C. French*); Hawthorn, on a palm (*R. Kelly*) ; Lake Hattah, Mallee, on *Heterodendron oleaefolium* (*J. E. Dixon*).

The latter material has a much reduced and much more sharp-pointed second pair of lobes than is customary in *A. hederae*, but otherwise there appear to be no other characters to separate it from typical specimens.

**Aspidiotus delicatulus,** sp. n. (figs. 9, 10).

Female puparium subcircular, flattish, pale grey, rather thin and papery in texture ; exuviae excentric, dull black or very dark brown ; diameter approximately 1 mm.

Fig. 9. *Aspidiotus delicatulus*, sp. n. : pygidium of adult ♀.

Adult ♀ broadly pyriform, conical behind, one-fourth longer than broad, body delicate and membranous, with the pygidium strongly chitinised. Antennal tubercles small and inconspicuous with a single stout curved seta ; a few very slender setae scattered around margin ; no parastigmatic pores ; a few very minute circular pores present on marginal area of thoracic and free abdominal segments. Pygidium sharply pointed with a large median pear-shaped area, with its apex pointing posteriorly, strongly defined ; a single median trulla, rather prominent, with the margin smoothly rounded ; immediately beyond, the margin projects shallowly, forming a process with a truncated apex, followed by two spiniform setae, two broader, curved processes, and finally two more setae ; lying well beyond is a strongly developed spur-like prominula, followed by two setae, and immediately lateral the margin widens out into a pronounced wing-like expansion, which merges with the margin again

where another spur is present ; perivulvar pores absent, dorsal pores present, small and inconspicuous, confined almost entirely to marginal area, an irregular double series along part of the base of the lateral wing-like expansion ; a few tubular, and groups of fine filiform, spinnerets, the latter mainly lateral in position. Length, 1·03 mm. ; breadth, 0·8 mm.

NORTHERN TERRITORY : Koolpinyah, on *Melaleuca leucodendron* (*G. F. Hill*).

This species belongs to the group for which MacGillivray has established the genus *Neoleonardia*, with type *extensus*, Mask., but it is most closely related to *alatus*, Frogg., as will be seen from the figure of the latter given here for comparison. The most conspicuous differences between the two lie in the development of a second

Fig. 10. *Aspidiotus alatus*, Frogg. : pygidium of adult ♀.

wing-like marginal expansion in *alatus*, the broader and more rounded, and altogether more prominent development of the corresponding (or second) expansion in *delicatulus*, and the presence in the one, and absence in the other, of the spurlike prominulae. This is one of the species which Mr. Green has turned over to me for description, and I have adopted the name which he had coined for it. He was inclined to treat it as a variety of *alatus*, but the differences seem to me sufficient to warrant specific rank, and I have treated it accordingly.

**Aspidiotus tuberculatus,** sp. n. (fig. 11).

Female puparium subcircular or oval, very low convex, black, with one or more flavous spots at apex of scale and around margin ; exuviae excentric, dull black or dark brown. Diameter, 0·57 mm.

Adult ♀ small, subcircular, narrowed posteriorly, membranous ; antennal tubercles with a single, strong, curved seta ; no parastigmatic pores ; dorsal surface devoid of setae and pores ; margin with a conspicuous series of large, flaccid, truncate

or broadly rounded tubercles, six on each side, resembling the claspers of a lepidopterous larva, and with striated surface. Pygidium with three pairs of trullae; median pair oval, the long axis of each inclined so that their apices approximate; second and third pairs triangulate; inner margin of second trulla with a conspicuous paraphysis, inner margin of third lobe with one about half its length; no squamulae present; two spines in each of the second and third intervals; no perivulvar pores; a conspicuous marginal series of five pairs of tubipores; pygidium without any other characteristic. Length, 0·46 mm. to 0·51 mm.

NORTHERN TERRITORY: Darwin, on *Melaleuca* (*G. F. Hill*).

This is another of the species which Mr. Green has turned over to me for study and descriptive purposes, and I have adopted the provisional name which he had assigned it. The material is so scanty that proper study has been impossible, and its

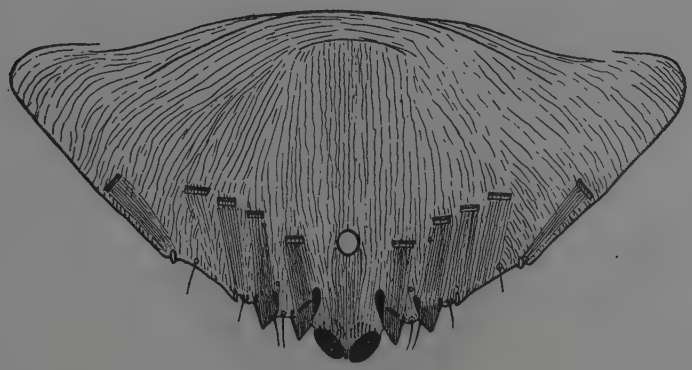


Fig. 11. *Aspidiotus tuberculatus*, sp. n.: pygidium of adult ♀.

resting place in *Aspidiotus* is nothing more than provisional; the remarkable tubercular lateral processes and the pygidial characters will, without doubt, warrant the erection of a new genus when it has been properly studied.

**Aspidiotus subrubescens,** Mask.

VICTORIA: Balwyn, on *Loranthus pendulus* (*C. French*).

**Aonidiella aurantii,** Mask.

NEW SOUTH WALES: Sydney Botanic Gardens, on *Cactus* (*C. French*); Nowra, on lemon (*F. R. Rodway*). VICTORIA: Melbourne, on *Cypripedium* (*C. French*).

**Aonidiella subrossi,** sp. n. (fig. 12).

Female puparium subcircular, flattish with a slightly raised median nipple, dull black, opaque, surface roughened; exuviae central, obscured by a black surface coating. Diameter approximately 1·5 mm.

Female circular to oval with the length nearly twice the breadth; body soft, membranous except for pygidium. Marginal area of body with numerous slender setae and a few tubular spinnerets, especially on that part lying between the two pairs of spiracles; antennal tubercles with a single, very long, spiniform seta; spiracles without parastigmatic pores. Pygidium with three pairs of trullae, the median pair the largest, the second and third pairs decreasing slightly in size, the inner margin of each straight, the outer conspicuously notched; margin laterad of

third pair with four low, broad-based triangular processes, serrated on their long outer margin; the usual number of squamae in the intervals between the trullae, four beyond the third pair; six pairs of paraphyses, all about equal in size; no perivulvar pores; tubipores conspicuous in the central area; dorsal glands numerous submarginally on the area lying adjacent to the serrated part of the margin and a uniserial row arising from the second lateral interval. Length about 0·8 mm.; breadth, 0·5 mm.

New South Wales: on *Acacia rubra* (*W. W. Froggatt*).

In the general appearance and pygidial characters this species resembles *Chrysomphalus rossi*, Mask., but the absence of perivulvar pores would place it in

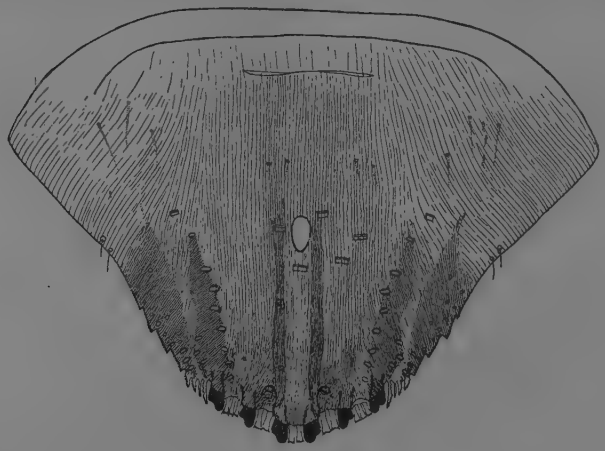


Fig. 12. *Aonidiella subrossi*, sp. n.: pygidium of adult ♀.

*Aonidiella* according to our present somewhat artificial system of classification. I am indebted to Mr. Green for this material and I have adopted the name he provisionally gave to the species.

**Furcaspis cladii,** Mask. (fig. 13).

Victoria: Bendigo, on *Gahnia* (*J. E. Dixon*).

For the present I am leaving this species in the genus *Furcaspis*, where it has been assigned by some, but it is obvious that it cannot remain here, for it has little in common with the genotype, *biformis*, Ckll. It does, however, come close to *oceanica*, Ldgr. MacGillivray has made *cladii* the genotype of his *Paraonidiella*, but has assigned *oceanica* to his genus *Spinaspidiotus*; but until due consideration has been given to the status of the many genera erected by that author, it is better to adopt a conservative policy. I present a new figure which may serve as a comparison with that given by Green (Jour. Econ. Biol. v, 1910) for *F. oceanica*, Ldgr.

**Chrysomphalus fodiens,** Mask. var. **albus,** nov.

This variety differs from the typical species only in the colour of the female puparium, which is dead white instead of being of a uniform brown.

Northern Territory: Darwin (*G. F. Hill*).

**Chrysomphalus rossi,** Mask.

VICTORIA: Bendigo, on *Styphelia* sp. (*J. E. Dixon*); Broadmeadows, on *Eucalyptus* (*G. F. Hill*); Hawthorn, on *Euonymus* and olive; and Burnley Gardens, on *Nerium oleander*, *Eucalyptus rostrata*, *Pittosporum undulatum*, and *Veronica* (*R. Kelly*).

Fig. 13. *Furcaspis cladii* (Mask.): pygidium of adult ♀.

**Pseudaonidia stenophyllae,** sp. n. (fig. 14).

Female puparium not observed.

Adult ♀ clearing completely in caustic potash except for the dorsal area of the pygidium, which is more or less chitinized; insect flaccid and soft; broadly pyriform, the breadth almost equal to the length, the cephalic region demarked from the remainder of the body, rounded in front, shallow, not so broad as the thoracic region. Antennal tubercles with a short, stout seta; anterior pair of spiracles with a small group (4–5) of parastigmatic pores, posterior pair without; cephalothorax with a few short slender setae scattered over dorsal surface; metathorax and abdominal segments with a few pores on marginal area; abdominal segments each with a single arch of round thick-rimmed pores sublaterally. Pygidium with the median pair of lobes well developed, sub-rectangular, the inner and outer margins more or less parallel, the apical broad, faintly notched in two places with the section between curving gently outwards; second pair of lobes very much smaller, the sides parallel basally, curving apically to form a shallow cone; margin beyond with a few strong spines and a couple of squamiform setae; the outer margin of median lobe prolonged inwardly at base to form a paraphysis capped by an oval or crescentic chitinous thickening; anal pore small, lying above median lobes at a distance about equal to their length; median area of pygidium densely chitinized and tessellated, the tessellations rather large; no perivulvar pores; dorsal pores few, confined to a few

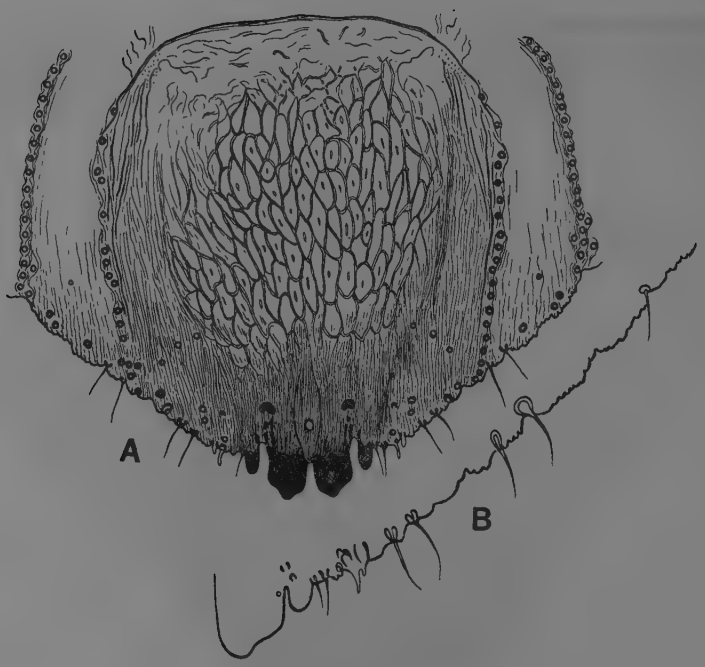



Fig. 14. *Pseudaonidia stenophyllae*, sp. n.: A, pygidium of adult ♀; B, pygidial fringe.

submarginal pores, and a single, more or less continuous, arch. Length, 0·6 mm.; breadth, 0·55 mm.

VICTORIA: on the Murray River, near Hattah, on *Acacia stenophylla* (*J. E. Dixon*). Described from a single specimen found along with *Targionia acaciae* (Morg.).

Fig. 15. *Targionia subfervens*, Green: pygidium of adult ♀.

**Targionia subfervens,** Green (fig. 15).

VICTORIA: an unknown locality, on *Acacia melanoxylon*, and Shepparton, on *A. pycnantha* (*C. French*); Broadmeadows, on *Eucalyptus* sp. (*G. F. Hill*).

The accompanying figure may serve to make this interesting species more easy of recognition; it gives a little more detail than that furnished by Green.

**Targionia acaciae,** Morg. (fig. 16).

VICTORIA: Mallee, on *Acacia* sp. (*J. E. Dixon*).

The figures which have hitherto appeared of this pretty species have failed to convey its characters; that given by Morgan is quite erroneous so far as the median lobes are concerned, and that of Leonardi (Riv. Patologia Veget., viii, p. 309, 1901)

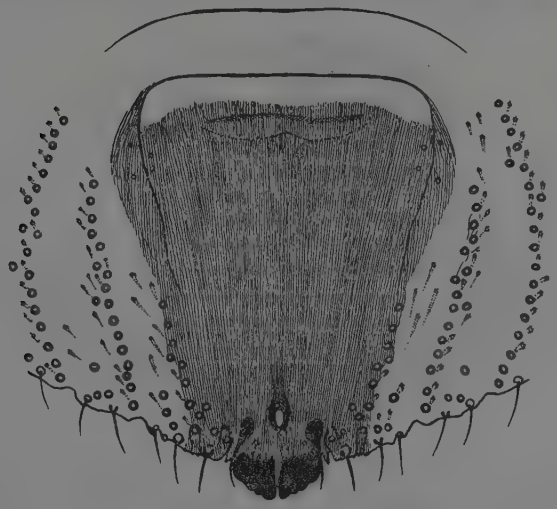


Fig. 16. *Targionia acaciae*, Morg.: pygidium of adult ♀.

deals only with the margin of the pygidium. I present another, and more detailed, figure in the hope of making *T. acaciae* more recognisable.

**Lepidosaphes hilli,** sp. n. (fig. 17).

Female puparium mytiliform, moderately convex at the middle, rather short, broad behind, snow-white; exuviae orange red, the nymphal pellicle overlaid by a thin layer of wax. Length, 2 mm.

Male puparium broadening out very slightly posteriorly, white, non-carinated; pellicle warm castaneous brown.

Adult ♀ becoming entirely membranous in caustic potash, ovate, rather narrow in front, broadest across the first abdominal segment, the breadth there about three-fifths the length. Antennal tubercles minute, apparently sunk in small pits; anterior pair of spiracles with a small group (4–5) of parastigmatic pores, posterior pair without; setae on cephalic region very short and sparse; filiform spinnerets present on marginal area slightly in front of anterior spiracles and on subsequent segments, becoming larger and more numerous on metathorax and abdominal

segments, and on the latter dividing into lateral and submedian series; short tuberculate spines also present sublaterally on meso- and meta-thorax; lying a little in front and to the rear of the posterior spiracle, but slightly more median, is a strong ventral tubercle, that in front (on mesothorax) usually either duplicate or triplicate. Pygidium with the mesal trullae projecting slightly, divergent, united basally by a chitinous bar, denticulate on both outer and inner margins, but the exact shape liable to some variation; second trulla duplex, the inner lobule well developed, entire, parallel-sided, rounded apically, outer lobule small, subconical or triangulate; margin beyond so soft that a constant shape cannot be obtained in a preparation, but it usually consists of a number of narrow or broad prominences and marginal gland orifices; a single spiniform squama in the usual positions; perivulvar pores in five groups, the formula 19, 13, 5–6, 15, 17; dorsal glands numerous, the first series consisting of 6–9 posteriors and 4–5 anteriors, the second series of 10–13 posteriors and 7–8 anteriors. Length, 1·3 mm.

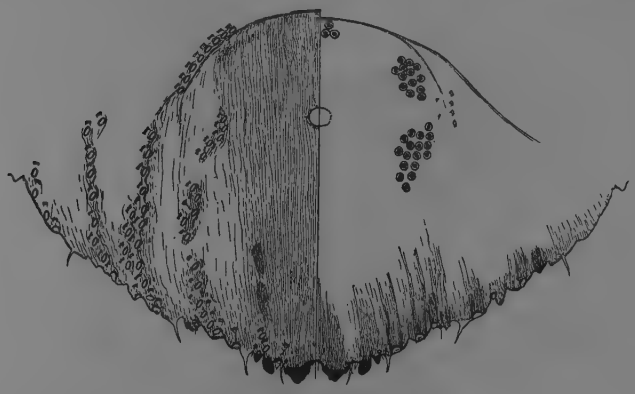


Fig. 17. *Lepidosaphes hilli*, sp. n.: pygidium of adult ♀.

New South Wales: Biniguy. S. Queensland: Chinchilla, on *Casuarina* sp. (*G. F. Hill*).

I had at first treated both these lots of material as *L. casuarinae* (Mask.), because of the similarity of the external appearance, but Mr. E. E. Green, to whom I submitted specimens, does not consider that it is Maskell's species, or if it is, it is not typical; according to a sketch he sends me the mesal trullae in *L. casuarinae* are quite separate, not united basally, nor are they so pronounced and projecting; the second trulla would appear to be inconspicuous or absent. This would agree with a single mount in my possession of what purports to be *L. casuarinae* found on *Casuarina* sp. in Victoria (I am unaware of the authority who determined it) where the second trulla is absent, as are also the numerous posterior orifices of the first dorsal series. Leonardi figures (if one may rely on his figure; Maskell's description is worthless, and MacGillivray simply translates Leonardi's description) the second trulla as very broad, broader than the mesal, and denticulate on both margins, whereas the whole of my series show the second trulla very distinctly duplex. It may be that these distinctions are due to a large extent to the soft, membranous nature of the pygidial fringe, or else that there are more than one species of similar external appearance masquerading under the same name; so on the whole I consider it advisable in the present uncertainty to treat these two lots of material as representing a separate species. The holotype has been selected from the Biniguy material.

**Lepidosaphes hartii,** sp. n. (fig. 18).

Female puparium of the normal mytiliform shape, white, slightly waxy in appearance, smooth, quite three times as long as the breadth posteriorly ; exuviae warm reddish brown, the nymphal pellicle overlaid by a thin layer of whitish secretion. Length, 3 mm.

Male puparium resembling that of the female in shape, though not quite so broad posteriorly, white but not waxy, more woolly in texture ; pellicle pale stramineous. Length, 1·5 mm.

Adult ♀ clearing completely in caustic potash, derm membranous, rather narrow in front, widening out to the prepygidial segment, then contracting sharply to form a low, broad pygidium. Antennal tubercles with a stoutish, straight seta, and another smaller, more slender one ; anterior pair of spiracles with a small group (4–5)

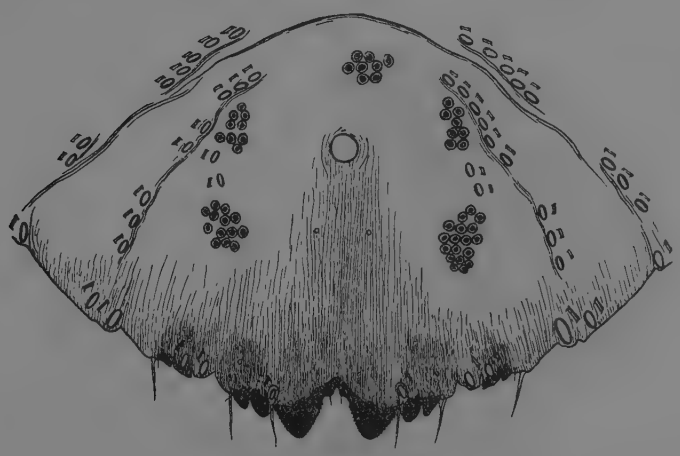


Fig. 18. *Lepidosaphes hartii*, sp. n. : pygidium of adult ♀.

of parastigmatic pores, posterior pair without ; cephalic region with sparse, very short, slender setae, and a few minute filiform spinnerets mainly on submarginal area ; marginal area of segments from the mesothorax backwards with numerous tubipores, these dividing on the prepygidial abdominal segments into a distinct lateral and submedian series ; each of these segments also with a submedian group of small tubercles, which become larger, and more marginal on the last one or two free abdominal segments, showing them to be in the nature of fistulae. Pygidium with the median pair of trullae strongly developed, projecting, subconical, with rounded, entire margins, and finely serrated, well separated but united basally by a thick chitinous bar ; second pair of trullae duplex, the inner lobule the larger, rounded apically, the outer subtriangular ; third pair of trullae absent, but their position marked by a slight double invagination of the margin ; a pair of minute setae in the median interval, a spiniform squamula immediately beyond the median, first lateral, and the position of the third trullae ; a marginal gland orifice in first lateral interval, and two beyond the first lateral trullae ; a pair of anterior dorsal pores in the first position, the second arch composed of 2–3 posteriors and 6–7 anteriors ; perivulvar pores in five groups, the formula 14,10, 4–8, 8,19. Length, 0·8 mm.

Victoria : Gippsland, Bairnsdale, on *Banksia serrata* (*T. S. Hart*).

This species is probably most closely related to *L. grandilobis* (Mask.), but the median pair of lobes, though of the same general shape, are considerably shorter and broader, and more widely separated, while the second pair, though small, are quite well defined and not reduced to minute triangular projections, such as they are in *L. grandilobis*, nor are the spiniform squamulae so numerous nor so strongly developed. The figure of *L. grandilobis* given herewith (fig. 19) may serve to make the distinctions more obvious.

**Lepidosaphes pandani,** sp. n. (fig. 20).

Female puparium linear, parallel-sided, very slightly expanded at anterior end, or widening out gently at the median area, six to eight times as long as broad, rich castaneous to dark brown, with a narrow area on anterior margin much paler, surface

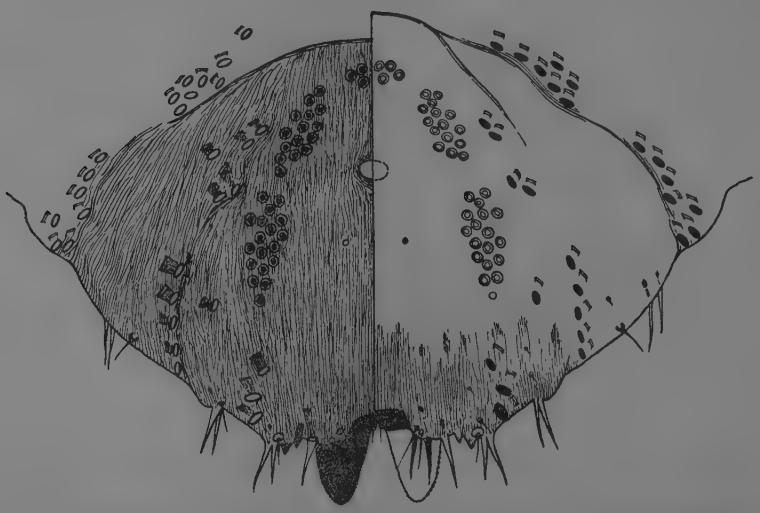


Fig. 19. *Lepidosaphes grandilobis* (Mask.) : pygidium of adult ♀.

with transverse ridging, the distance between ridges varying considerably ; exuviae pale yellowish brown, the nymphal somewhat darker than the larval. Length up to 4 mm.

Adult ♀ of the normal shape, membranous, widest across abdominal segments, the length from two and one-half to three times the breadth ; antennal tubercles with two short, stoutish setae and one more slender ; anterior pair of spiracles with a small group (3–4) of parastigmatic pores, posterior pair without ; metathorax with a few very minute filiform spinnerets on marginal area ; abdominal segments projecting somewhat laterally, the anterior with lateral groups of very minute tubercles, these increasing in size considerably on the posterior. Pygidium with two pairs of well-developed trullae ; median pair contracted at base, widening out into a rounded free margin, usually a very distinct notch on both outer and inner sides, but occasionally this notch almost obliterated ; second trulla duplex, the first lobule the larger, both of very similar shape, the inner margin straight, the outer curving

round to meet it at an acute angle, but sometimes both margins diverge at almost equal angles from the base and with a round apical margin ; in the position of the third pair of trullae the margin is expanded into a broad, flat, lobe-like structure; squamulae in normal positions ; marginal gland orifices large, conspicuous, two beyond second trullae and two still more lateral ; perivulvar pores in five groups, the formula 9, 13, 5, 12, 10 ; a number of small circular pores on dorsal surface, one group towards the middle line and more or less posteriorly, the other more lateral and extending farther forward. Length, 1·2 mm.

NORTHERN TERRITORY : Koolpinyah, on *Pandanus odoratissimus* (*G. F. Hill*).

I also assign to this species some examples of a *Lepidosaphes* found by the same collector at Darwin, N. Territory, on *Alstonia*. Mr. Green, to whom I am indebted for the preparations of specimens from both hosts, inclined to the view that those from *Alstonia* represented a distinct species, but my examination has failed to convince

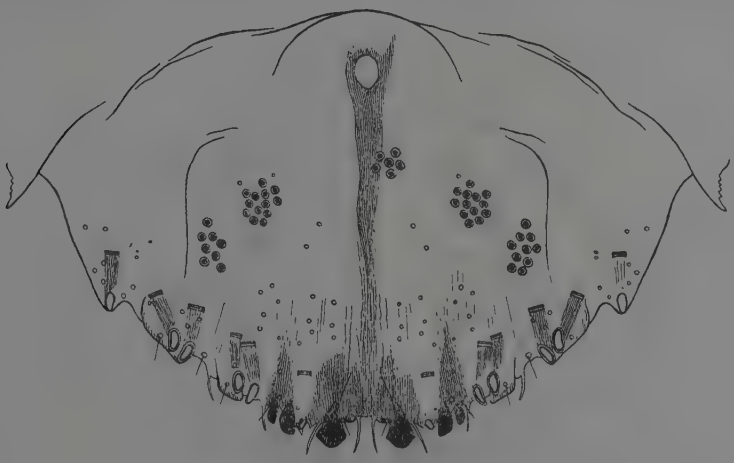


Fig. 20. *Lepidosaphes pandani*, sp. n. : pygidium of adult ♀.

me that satisfactory characters exist to separate it off. It is true that the median lobes are more rounded and fail to show the notching on the outer and inner margins, but this point may also be observed to occur in specimens on *Pandanus*. The only character that may be of importance is the marginal expansion at the position of the third pair of trullae ; in specimens from *Pandanus* it is perhaps a little deeper than in those from *Alstonia*, but the mounting may explain this slight difference. For the present I prefer to unite the collections from the two hosts.

**Lepidosaphes chitonosa** (Frogg.).

*Mytilaspis chitonosa*, Froggatt, Agr. Jour. New S. Wales, xxv, p. 607, 1914.

It would appear as if Froggatt's specific name were preoccupied by *Lepidosaphes chitinosa*, Ldgr. (Jahrb. Hamb. wiss. Aust., xxvi, 34, 1909), for though the derivation might probably be held to be different and there is a difference of one letter, I think it is really a printer's error. To prevent confusion I propose the name **L. froggatti.** The fact that Froggatt used the generic name of *Mytilaspis* in preference to *Lepidosaphes* does not affect the question.

**Lepidosaphes bicornis,** Green, var. **alba,** Green.

VICTORIA: Mallee, Lake Hattah, on *Eucalyptus rostrata* (*J. E. Dixon*).

**Lepidosaphes subnivea,** sp. n. (fig. 21).

Female puparium of the usual mytiliform shape, usually rather convex in front or towards the middle, with steepish sides, and often not very expanded posteriorly, owing doubtless to the narrowness of the leaves of the host-plant, white with a distinct waxy appearance; exuviae warm yellowish brown, the nymphal pellicle often overlaid by a thin covering of wax. Length, 2 mm.

Male puparium parallel-sided, or slightly expanded posteriorly, snow-white, somewhat woolly, non-carinated; pellicle warm yellowish brown. Length, 1·7 mm.

Adult ♀ of the usual mytiliform shape, about twice as long as broad; membranous; antennal tubercles each with one long seta; anterior spiracles with a small group (3–4) of parastigmatic pores, these absent from the posterior pair; mesothorax with a few tubipores and small tubercles lying sublaterally; marginal area of

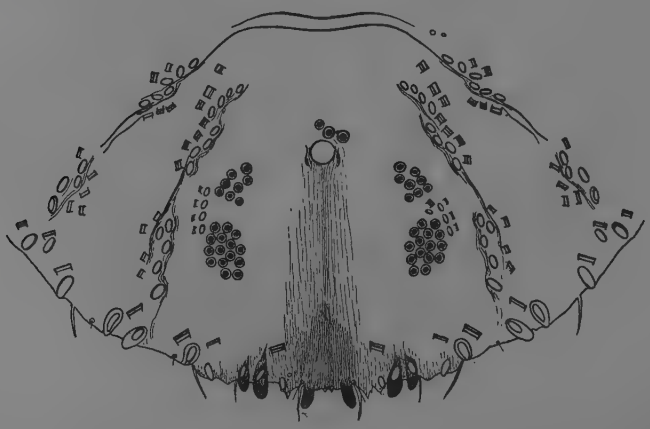


Fig. 21. *Lepidosaphes subnivea,* sp.n.: pygidium of adult ♀.

abdominal segments, and to a lesser extent the metathorax, with numerous tubipores intermixed with one or two small tubercles. Pygidium with two pairs of trullae, the median pair prominent, ligulate, entire, with apices slightly conical owing to the oblique direction of the inner margin, widely separated, the interval between being slightly greater than the length of one trulla; second pair of trullae duplex, the first lobule slightly broader than the median, not so protruding, the inner margin straight, the outer curving right from the apex to the base, second lobule much smaller but of the same general shape, both with a gland pore at base; laterad of second pair of trullae are two pairs of large, conspicuous marginal gland pores; two minute setae in the median interval, and a single fistula in the second interval and immediately beyond the second trulla; five groups of perivulvar pores, the formula 16, 9, 4, 7, 18, median group sometimes broken up into two to three subsidiary groups of 1 to 3 pores each; first series of dorsal gland orifices composed of 3–5 anteriors only, the second series with 5–6 posteriors, and 6–7 anteriors. Length, 0·9 mm.

VICTORIA: Dimboola, on *Calycothrix tetragona* (*C. French*).

The pygidial characters are ample to separate this species from *L. nivea* (Mask.), in particular the distance separating the median pair of lobes. In *L. nivea* these are nearer together and united basally by a chitinous bar, while they are also of a totally different shape (cf. Leonardi's fig. in Ann. Scuola Sup. d'Agric. Portici (2), v, p. 53, 1904). It is possible that the record given by Froggatt (Science Bull. 14, Dept. Agr. N. S. Wales, p. 44, 1915) of *L. nivea* occurring on this host-plant actually refers to this species.

**Lepidosaphes defecta,** Mask.

W. AUSTRALIA: Perth, on an unrecorded host (*Dr. G. A. K. Marshall*).

The pygidium is membranous and so soft that it is almost impossible to obtain a constant outline of the fringe. The figure given by Leonardi (Ann. Scuola Sup. d'Agric. (2), v, p. 34, 1904) seems to be on the whole fairly correct, though he shows the lobes a little too large.

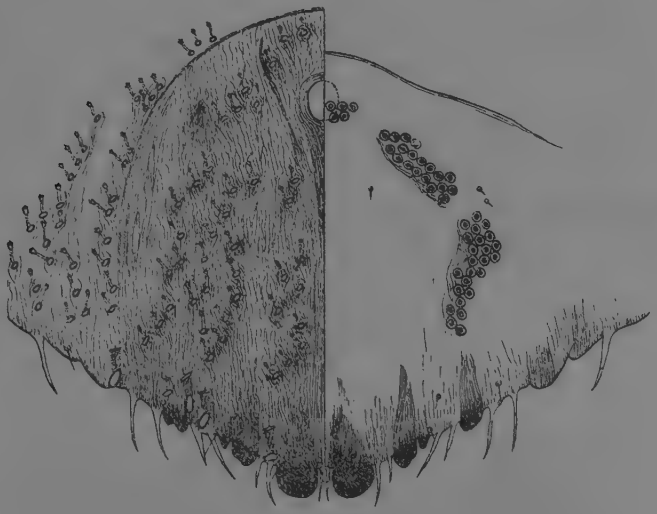


Fig. 22. *Lepidosaphes contorta*, sp. n.: pygidium of adult ♀.

**Lepidosaphes contorta,** sp. n. (fig. 22).

Female puparium of normal mytiliform shape, elongate, curved or twisted into various shapes, dark castaneous brown, often darker from adhering bark debris or sometimes with a faint greyish appearance; ventral scale ruptured in middle, whitish grey, often left on bark when scale removed; exuviae yellowish brown, nymphal pellicle much darker owing to a thin covering similar to puparium proper. Length, 3 mm.

Adult ♀ clearing completely in caustic potash, membranous, pygidium somewhat darker, elongate oval, narrow in front, widest across first abdominal segment, the length considerably more than twice the breadth. Antennal tubercles with two fairly long, stoutish setae and 2–3 minute tubercles; anterior pair of spiracles with a large cluster (12–14) of parastigmatic pores, posterior pair without; cephalic region with scattered setae; tubipores on marginal area of mesothorax and subsequent segments, on last free abdominal segments these reaching submedian region; a few small

tuberculate spines submedianly on metathorax and first abdominal segment; a few marginal spinulae on last three prepygidial segments. Pygidium with the mesal trullae well developed, prominent, much broader than long, entire, parallel-sided at base, rounded and somewhat oblique apically; second pair duplex, but not projecting much beyond margin, inner lobule broad, truncate and usually notched apically, the second lobule small, subconical; third pair represented by a broad, shallow, bicuspid projection; two spiniform squamulae in each interval and beyond third trulla and spines in usual positions; perivulvar pores in five groups, the formula 28, 19, 10–12, 14, 20, the anterior lateral and median groups often confluent; dorsal gland orifices very numerous, rather small, their ducts long and very distinct, scattered fairly generally over whole surface, though on the whole they may be divided roughly into a median, submedian and lateral series. Length, 1·6 mm.

TASMANIA: Ross Midlands, thickly infesting the bark of *Acacia* sp. (*G. F. Hill*).

This species bears a close relationship to *L. multipora*, Leon., described from specimens found on *Pittosporum undulatum* in New Zealand, but Mr. Green considers that the two are amply distinct and has furnished me with some cotype material of *L. multipora*. This has the mesal interval slightly wider, the mesal trullae markedly notched on the outer and usually also on the inner margin, the inner lobule of the second trulla slightly narrower, the third of a slightly different shape, the dorsal glands not so numerous, etc. Froggatt, in his Catalogue, records *L. multipora* as being found on *Acacia stricta* in Victoria, but he states that the median trullae have serrated sides. This determination is open to doubt, for the cotype specimens show no serration of the median lobes.

**Berlesaspis spinifera,** Mask. (fig. 23).

Female puparium snowy-white with a slight waxy sheen, very broadly pyriform, the breadth, if anything, greater than length, faintly ridged concentrically, looking,

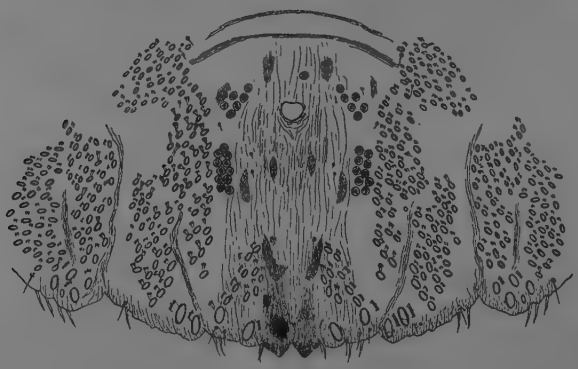


Fig. 23. *Berlesaspis spinifera* (Mask.): pygidium of adult ♀.

as Froggatt says, "like a little white limpet-shell"; exuviae very pale stramineous, the nymphal pellicle overlaid by a thin layer of wax. Length, 2·2 mm.

Male puparium elongate, narrow, widening out very slightly posteriorly, white, rather papery in texture, non-carinated; pellicle very pale brownish yellow. Length, 1·5 mm.

Adult ♀ clearing completely in caustic potash, derm membranous, broadly oval, breadth four-fifths the length, greatest beyond the middle; antennae consisting

of a minute tubercle with a short capitate spine (often missing), the whole lying in a small pit; anterior spiracles with 3–6 parastigmatic pores, posterior pair without; cephalic area with sparse, slender, trichiform setae; tubular spinnerets numerous on the whole of the anterior part of the body, becoming still more abundant on thoracic segments, more especially marginally, while on abdominal segments they are confined almost entirely to marginal area, and densely crowded; stout spiniform setae, on pronounced bases, present, a few immediately posterior to anterior spiracles, another much larger group behind posterior spiracles, followed by a still larger and better defined cluster, somewhat more lateral, while on the abdominal segments these spines are sparsely intermixed with the marginal gland orifices, and also form small groups more medianly; a few fistulae on margins of abdominal segments; a very short, strong spine immediately in front of each spiracle, and another some little way behind the posterior ones. Pygidium broad and shallow, the margin very weakly chitinised, so that it is difficult to get a constant shape in preparations; a pair of median lobes weakly developed and, when discernible, scarcely projecting beyond margin, triangular in shape; no other lobes nor pygidial fringe, but a few rather strong spines, apt to be broken off; a few thick-walled, large, oval marginal and sub-marginal gland pores; dorsal gland pores densely crowded and occupying practically the whole of the submedian and lateral area, only a narrow median area being without; perivulvar pores in five groups, the formula 13, 6, 1–3, 6, 10. Length, 1·1 mm.

Redescribed from specimens collected by Mr. G. F. Hill, at Chinchilla, S. Queensland, on "brigalow" (*Acacia* sp.). This determination has only been rendered possible through named specimens, presented by W. W. Froggatt, the collector of the material from which Maskell selected the type, but the description which Maskell gives is very incomplete, while his figures are actually misleading, and Froggatt adds no details of any help. The figure I give may render identification easier. The species is not a typical *Lepidosaphes*; in fact, it is extremely doubtful whether it comes within the LEPIDOSAPHINI, and I think MacGillivray was quite justified in creating a new genus for it. Judging from the variation in size of the female puparia before me, there would appear to be little justification for the existence of Maskell's variety *major*.

## AN ADDENDUM TO Mr. F. D. GOLDING'S "NOTES ON THE BIONOMICS OF COTTON STAINERS (*DYSDERCUS*) IN NIGERIA."

By W. E. China.

In the February number (1928) of this Journal, a most interesting and valuable paper was published by Mr. F. D. Golding, Government Entomologist of Nigeria, on the bionomics of cotton-stainers (*Dysdercus*). In a footnote on page 319 of this paper it was suggested on my authority that three of the seven species mentioned by him as occurring in Nigeria were probably wrongly identified, since no representatives of these three species were present in the Nigerian material in the British Museum. Since then I have been able to examine Mr. Golding's collection and can state definitely that the specimens of *Dysdercus nigrofasciatus*, Stål, and *D. migratorius*, Dist., taken in Nigeria, were correctly identified. *D. intermedius*, Dist., however, does not, so far as is known, occur in Nigeria. To the species mentioned by Golding as occurring in that country must be added *D. antennatus*, Dist., which however is probably generically distinct from typical *Dysdercus* species.

# NOTE ON THE LIFE-HISTORY OF THE FIG-TREE MOTH, *OCNEROGYIA AMANDA*, STAUD. (LYMANTRIIDAE).

By Hugh Scott, M.A., Sc.D.

The following notes are written in the hope of supplementing what has been already published on the life-history of the Fig-tree Moth. In particular, the length of duration of the separate larval instars does not seem to have been given before. The observations began with the finding, on 27th May 1928, of caterpillars and eggs on fig-trees at Karradah, on the left bank of the Tigris below Baghdad. They were continued mainly in the entomological laboratory of the Agricultural Institute at Rustam, a few miles away, and were perforce discontinued after 21st June, as I had then to leave Baghdad on a tour of inspection and, shortly after my return, I fell ill.

## Habits in the Open.

The eggs collected on 27th May were in patches on the trunks and on the underside of the leaves, from a few inches above the soil to a height of about ten feet. Caterpillars in several stages of growth were found on the undersides of the leaves high up in the trees, even though the time of day was 10–11 a.m. They have been previously recorded[1, 2] as feeding almost entirely at night and hiding by day from the fierce sun in crevices of the soil or bark or among dead leaves, though they might occasionally be found even by day on the upper or lower surfaces of the green leaves on the trees. The tendency to seek shelter on the underside of the leaf seems to be inherited, for larvae one day old, hatched in the laboratory and sheltered from all direct sunlight, were observed feeding on the undersides of leaves ; this observation was made in the morning. On 9th June some pupae were found at the bases of the trees on the trunks. Pupation also occurs in crevices in the soil.[2] In the laboratory most of the larvae span their cocoons on the wooden roof of the breeding case.

## Damage to Trees.

In the fruit gardens visited some fig-trees were very badly attacked by this pest, while others near by were not, or only very little, attacked. Trees close to the mud walls surrounding the enclosures had suffered worst, perhaps because the pest thrives better where there is shade at certain times of day. It is noteworthy, however, that the leaves at the tops of the trees were just as badly attacked—sometimes eaten right away, excepting a few larger veins—as the lower leaves, and this very exposed foliage was doubtless devoured at night.

## Duration of Stages.

The larvae collected on 27th May span their cocoons between 30th May and 2nd June (inclusive). By 3rd June several larvae had pupated in their cocoons. The first emergence of an adult (sex not noted) took place on 7th June and emergences continued till 18th June, the last to emerge being all females. About seven of that sex emerged on, or shortly before, the 18th. Two pairs found *in coitu* on 9th and 10th June respectively were isolated and became the parents of series which were watched through part of their larval life.

A few full-grown larvae were still to be found in a wild state on 9th June, together with pupae, many cast larval skins, and one or two adult females. Larvae of the next generation, just hatching from eggs, and others a little more grown, were found on the same date.

Observation of the families isolated in the laboratory indicated that at this season the egg-stage lasts 5 or 6 days, while larval life occupies about 21 days, the five separate stages lasting, respectively, approximately 3, 5, 3–5, 3–5, and 3–4 days. The limits of the last three instars cannot be given more precisely, as the larvae of a single family did not all moult simultaneously. For example, in one family the third-stage larvae had nearly all moulted to the fourth stage by 12th June, but some were not seen to have completed their moult till the 14th.

Among the individuals of the preceding generation, which began to pupate in captivity about 3rd June, the pupal stage occupied in one case only 4 days, but in most cases several days more.

The periods tally fairly closely with those given in Ramachandra Rao's work,[2] namely 24 days for the larval period and 8–11 days for the pupal.

Buxton[1] found the moth to be continuous-brooded from the end of July to the end of September. My observations show that at least one generation, from egg to adult, had been passed through and the eggs of another had been laid, before the end of May. The broods no doubt succeed one another throughout the summer, a condition which (as Buxton remarks) is exceptional among Mesopotamian Lepidoptera, in which there is usually a slowing-up of the life-cycle during the great heat.

* * * * * * * * * *

One of the two females which paired and were isolated for observation laid about 120 eggs, the other much fewer. Buxton found the eggs in patches of from 20 to 100.

Dry summer weather was, of course, at its height during the taking of these observations. The temperature rose daily to well over 100° F., but not usually to the high figures, above 110°, experienced later in the summer. In the laboratory it was considerably less.

For full descriptions of larva and adult, with figures of the former and remarks on the distribution of the moth within the confines of 'Iraq, reference must be once more made to Buxton's work.

*References.*

(1) Buxton, P. A. A Liparid Moth (*Ocnerogyia amanda*, Staud.) destructive to Figs in Mesopotamia.—Bull. Ent. Res. xi, pp. 181–186, 1920.

(2) Ramachandra Rao, R.S.Y. A preliminary List of Insect Pests of 'Iraq.—Department of Agriculture, 'Iraq, Memoir No. 7, pp. 28, 29, 1921.

# EXPERIMENTS ON THE CONTROL OF THE PINK BOLL-WORM IN EGYPT.

By N. W. Barritt, M.A.,
*Late Senior Botanist, Cotton Research Board, Egypt.*

C. B. Williams[1] has shown that at the time of the first picking, *i.e.*, about the second week of September, the extent of attack by *Platyedra gossypiella* averaged 75 per cent. of the bolls during the years 1916 to 1924, and that at the end of September the percentage had risen to 90–95. He also showed that there is a definite correlation between the date of maturity of the crop and the development of the attack.

According to Bishara[2] the total amount of cotton crop actually lost in Egypt due to this pest averages 35 per cent. Realising the economic importance of this loss the Government adopted vigorous measures for the control of this insect.

These measures include: (1) compulsory ginning of all seed cotton before May; (2) heat treatment of all seed cotton.

These measures have been enforced throughout the country since 1919, and it is a remarkable fact that the figures given by Williams in his bulletin on the seasonal variation of this pest show no significant change in the extent of the attack since this date. These figures show that the attack begins with about 5 per cent. infestation at the beginning of July, increasing to 15 per cent. in the first week of August, then rapidly rising to 60 per cent. and 70 per cent. in the first week of September, after which every boll is attacked.

It seems very probable that this development of the attack is the natural rate of increase of the insect when an abundant supply of bolls is available, and that the occurrence of only a few adult insects in each locality in June is sufficient to produce 100 per cent. attack in September.

Thus, although the measures adopted to control this pest may destroy 98 per cent. of the hibernating larvae, the existence of larvae or pupae in fallen bolls buried in the soil and in bolls on cotton sticks stored for fuel is quite sufficient to start the outbreak in July. The result of this flaw in the control measures was predicted by Gough[3] in 1916, when he asserted that seed treatment alone could not be expected to give any appreciable results.

Unfortunately it has not been found practicable to destroy the infested bolls which fall to the ground or those which are stored on cotton sticks near every native dwelling. The adoption of some sort of control measures during July would therefore appear desirable. No previous experiments in the control of this pest during the summer months seem to have been attempted. In fact, opinion appears to have been against it, since Gough stated that this pest can be most effectively controlled between the picking season and the time of sowing. The reasons for this are not obvious and later experience has not confirmed it. In fact all the evidence appears to point the other way and to indicate the summer period as being the most suitable time for control measures.

Considering the life-cycle of the insect as a whole, it is seen that the population reaches a maximum during the late autumn and falls to a minimum during June and July. In the absence of ratoon or perennial cotton, any adults maturing before July have little or no chance of propagating their species. Any measures that can

deal with the few adults appearing during July and August are likely to be more effective in protecting the crop than more wholesale methods of destruction carried out at other times. Poisons have been tried, but without result, since the larva feeds only within the boll. Several parasites of this insect are known to occur in Egypt and attempts are being made to introduce others.

Bishara has shown that the order of preference of the parts of the cotton plant for egg-laying are as follows: young bolls, flowers, bracts, young shoots, leaves, stems. The adult moth is never found in the daytime, so that the egg-laying takes place at night, when no cotton flowers are open. It is therefore extremely improbable that vision assists the moth in locating the parts of the plant suitable for egg-laying.

On the assumption that their tactile and olfactory organs direct the egg-laying moths, a preparation consisting of castor oil and resin was used as a deterrent spray. Castor oil was selected after numerous tests to find a strong smelling substance possessing the following properties: (1) persistence after exposure to the Egyptian sun for at least 14 days; (2) entire innocuousness to the leaves, flowers and bolls; (3) ready availability in large quantities.

A mixture of castor oil 3 parts and resin 1 part is readily emulsified in 10 per cent. ammonia.

Preliminary experiments were first carried out in July, using castor oil alone. At intervals of 10 days the progress of the attack was determined by taking 10 plants at random from each plot, stripping all their bolls and dissecting them for larvae. The results obtained are given in the following table.

TABLE I. *Experiments at Giza with Castor Oil alone.*

| Treatment. | Date of examination. | No. of bolls examined. | No. of bolls attacked. | No. of larvae. | Percentage of attacked bolls. | Average no. of larvae per boll |
|---|---|---|---|---|---|---|
| Control... ... ... | 4.viii.27 | 149 | 30 | 46 | 20·1 | 1·5 |
| | 14.viii.27 | 198 | 67 | 88 | 34·0 | 1·3 |
| | 25.viii.27 | 240 | 130 | 272 | 61·7 | 2·1 |
| | 4. ix.27 | 196 | 134 | 289 | 68·4 | 2·1 |
| 1 gallon of Castor oil per 500 plants on 24.vii.27 ... ... | 4.viii.27 | 165 | 9 | none (11 exit holes) | 5·5 | none |
| | 14.viii.27 | 198 | 13 | 7 | 6·6 | 0·5 |
| | 25.viii.27 | 244 | 69 | 82 | 28·3 | 1·2 |
| | 4. ix.27 | 229 | 93 | 160 | 40·6 | 1·6 |

These results show that 10 days after spraying, no eggs had been laid on the bolls of the sprayed plants, though 11 larvae had matured and escaped from the 9 attacked bolls. During the same period the control plot showed that 20 per cent. of the bolls had been attacked by larvae hatched during this period. The deterrent effect of the castor oil on the development of the attack is apparent throughout the whole of the five weeks, though it diminishes considerably after 20 days.

Having thus demonstrated the possibility of using castor oil as a deterrent, larger scale experiments were decided upon, using the oil-resin emulsion in water. Since the attack at Giza had now reached 68 per cent. it was necessary to arrange experiments in the more northern region of the Delta where the attack develops later.

TABLE II. *Experiments at Guemmaiza.*

| Treatment. | Date of examination. | No. of bolls examined. | No. of bolls attacked. | No. of larvae. | Percentage of attacked bolls. | Average no. of larvae per boll. |
|---|---|---|---|---|---|---|
| Control ... ... | 22.viii.27 | 150 | 52 | 90 | 34·5 | 1·7 |
| | 7. ix.27 | 114 | 89 | 120 | 78·1 | 1·4 |
| | 17. ix.27 | 116 | 106 | 201 | 91·4 | 1·9 |
| Sprayed with 1 gallon oil and resin per ¼-acre on 22.viii.27 and 7.ix.27 ... ... | 22.viii.27 | 150 | 52 | 90 | 34·5 | 1·7 |
| | 7. ix.27 | 161 | 104 | 120 | 64·6 | 1·1 |
| | 17. ix.27 | 130 | 109 | 174 | 83·8 | 1·6 |

In this experiment the deterrent effect of the castor oil emulsion is very slight, probably owing to the fact that one-third of the bolls were attacked before the spraying was carried out. The amount of foliage probably has some effect in encouraging the progress of the attack.

TABLE III. *Experiment at Mamal el Gezaz.*

| Treatment. | Date of examination. | No. of bolls examined. | No. of bolls attacked. | No. of larvae. | Percentage of attacked bolls. | Average no. of larvae per boll. |
|---|---|---|---|---|---|---|
| Control ... ... | 23.viii.27 | 150 | 40 | 60 | 26·7 | 1·5 |
| | 8. ix.27 | 89 | 52 | 57 | 58·4 | 1·1 |
| | 18. ix.27 | 150 | 97 | 116 | 65·0 | 1·2 |
| Sprayed with 1 gallon oil and resin per ¼-acre on 23.viii.27 and 8.ix.27 ... ... | 23.viii.27 | 150 | 40 | 60 | 26·7 | 1·5 |
| | 8. ix.27 | 100 | 44 | 33 | 44·0 | 0·75 |
| | 18. ix.27 | 117 | 33 | 26 | 28·2 | 0·8 |

In this experiment the initial attack of the pest at the time of the first spraying was 26 per cent. and after the second spraying the percentage attack was actually reduced from 44 to 28.

In both field experiments the effect of castor oil-resin emulsion as a deterrent was less marked than in the small scale experiment at Giza. There are two reasons for this, viz., the amount of castor oil per plant was much less, and the attack had made more progress before the treatment was applied.

These results are not conclusive evidence of the economic value of castor oil-resin emulsion in the control of this pest, but they do suggest the possibility of establishing some means of control along these lines. They also suggest the possibility of the use of protective belts of sprayed plants in fields that have not recently carried a cotton crop and in which buried bolls are not a source of infestation.

*References.*

(1) WILLIAMS, C. B. Seasonal Variation in Pink Boll Worm Attack in Egypt.—Bull. No. 67, Ministry of Agriculture, Egypt, 1926.

(2) BISHARA, I. Note on the Estimation of Loss by Boll Worms.—Bulletin No. 49, Ministry of Agriculture, Egypt, 1924.

(3) GOUGH, L. The Life History of *Gelechia gossypiella* from Harvest to time of Sowing.—Bull. No. 4, p. 10, Ministry of Agric., Egypt, 1916.

# A NEW SPRAY FOR SCALE-INSECTS ON CITRUS IN EGYPT.

By N. W. Barritt, M.A.,

*Late Senior Botanist, Ministry of Agriculture, Egypt.*

Citrus trees in Egypt suffer very severely from the attacks of scale-insects, especially the black scale, *Chrysomphalus aonidum*, which, when unchecked in its ravages, renders the cultivation of this crop impossible.

The usual method of control is by fumigation with hydrocyanic acid gas, which is conducted on a large scale by officers of the Ministry of Agriculture. This method, though very effective and comparatively cheap, suffers from the following defects :—

1. It is liable to damage the trees by scorching.
2. It must be carried out at night.
3. It cannot be carried out by the cultivator or by unskilled labour.
4. It cannot be applied to trees with overlapping branches or difficult of access.

The usual method of controlling scale-insects on fruit trees in temperate climates is by resin and paraffin washes, which, being injurious to foliage, can only be applied during the winter. Unfortunately, this treatment is unsuitable for Citrus trees, which are not deciduous and only mature their fruits in the winter months.

The writer endeavoured to overcome these difficulties by modifying the composition of the resin wash, so as to remove the substances injurious to foliage without diminishing, but rather increasing, the efficacy of the solution against the pest. The modified wash is made as follows : A mixture of 3 parts castor oil and 1 part resin is heated over a flame and stirred until the resin dissolves. This solution is converted into an emulsion by stirring into 50 parts of water containing 1 part of strong ammonia (·880). The emulsion so formed can be readily sprayed with any ordinary machine. On exposure to the air the water and ammonia evaporate, leaving a thin film of sticky varnish on the surface of the leaves. This film remains tacky even under tropical conditions for three or four weeks and proves fatal to both scale-insects and mealy-bugs. The varnish effectively seals up the female scale and prevents any possible migration of the young. No effect of the varnish on the assimilatory functions of the leaf has been observed, and it was applied with complete success on very heavily infested trees of the sweet orange on State Domain lands at Guemmaiza in the Egyptian Delta. Ten days after spraying not a single living scale could be found, and there was no sign of damage to the foliage.

Spraying may take place at any time during the summer months between March and October, so as to leave sufficient time for the fruits to outgrow the adhesive varnish, which, if applied later, would cause inconvenience in handling. Further, it may be applied by the cultivator himself or by unskilled labour, and the proximity of other trees does not interfere with its application. It also has the advantage that it can be applied piece-meal and without waiting until the attack of the pest has reached proportions large enough to justify an application for fumigation.

The use of this spray as a deterrent against pink boll-worm of cotton has been described above in this Bulletin, and it is suggested that it may have a more extended application to pests on *growing* crops in more temperate climates.

# THE BIONOMICS OF SOME TREE-HOLE MOSQUITOS.

By Mary V. F. Beattie, M.B., Ch.B., D.P.H.,
*Wandsworth Scholar, London School of Hygiene and Tropical Medicine ;*
and
Lucy J. Howland, M.Sc., A.R.C.Sc., F.L.S.

(Plates III & IV.)

## Introduction.

The investigation of the kinds of larvae, their environment and food, found in three tree-holes in Burnham Beeches, Buckinghamshire, is described in the following paper.

Part I, by M. V. F. Beattie, consists of the study of the physico-chemical factors of the environment.

In Part II, L. J. Howland deals with the study of the food, algal or otherwise, of the larvae.

## Part I.

*Physico-chemical Factors in Relation to Mosquito Prevalence in Rot-Hole Water.*

The chemical study of mosquito environments is not new, but it is a matter so complex that it has not yet told us much. Chemical factors are possible determinants of mosquito breeding. In order to increase our knowledge of this matter, investigations must be made in various parts of the world and results compared.

In February 1928 we commenced an investigation of certain physico-chemical changes occurring in the waters of three rot-holes in beech trees (*Fagus sylvatica*), selected by mosquitos as their breeding-place. A routine physical and chemical analysis has been carried out over a period of one year.

## Tree-Holes.

The three beech trees were situated near to one another in Burnham Beeches, Buckinghamshire. They are referred to as trees 1, 2 and 3 in Parts I and II of the paper. All the holes were in living trees.

Tree-hole 1 (Pl. iv, fig. 1) was very wide and deep. It penetrated from the aperture, at a point where a branch had been broken off, into the trunk of the tree. A walking stick could be pushed right into the hole. It contained a large amount of water at all times of the year. There was another smaller opening leading into the top of this hole, but very little light penetrated into the interior.

Tree-hole 2 (Pl. iii) was also very wide and deep, but apparently not quite so deep as hole 1. The main aperture was on the trunk of the tree ; the long diameter of the aperture was twelve inches and the cross diameter six inches. In this hole also there was another smaller aperture on the top ; again very little light could penetrate into the interior.

Tree-hole 3 (Pl. iv, fig. 2) was somewhat different. It had a broad opening, twelve inches by ten inches, at a point where a branch had been broken off, but the hole was shallow and did not reach far into the trunk. It was much more open, and light penetrated into it easily.

The openings of the three holes were about six to seven feet from the ground.

## Water.

The water of tree-holes 1 and 2 was generally clear and of a rich brown colour like strong tea ; the odour was very disagreeable. In tree-hole 3 the water was still darker and opaque ; as a rule there was no odour when water was plentiful.

The debris of tree-holes 1 and 2 consisted of a mixture of humus with leaves, whole and in fragments, and dead insects. The debris of hole 3 varied considerably. It was black and slimy, full of leaves and stones, and usually old tins and bottles. On one occasion pieces of orange and banana had been added by picnickers; this had the effect of changing the pH and the whole chemical content considerably.

**Effects of Physical Factors.**

During a considerable part of the year the tree-holes were protected from the effects of sun, wind, rain and temperature by the leaves. Tree-hole 3 was most easily affected by these factors as it was more open and shallower. In this hole the level of the water fluctuated considerably. On one occasion in July it dried up altogether; in October after heavy rain and wind the water overflowed.

**Method of Collecting Water.**

Water for chemical analysis was siphoned through a long piece of rubber tubing into 500 cc. bottles. The end of the tube inserted into the rot-hole was closed by a glass bead; two small holes were cut in the sides of the rubber tube. This allowed the water to enter easily and prevented blocking by leaves. By using a glass Y-piece and a spring clip it was possible to start the siphon without filling the mouth with water. A very easy method of inserting the tube into a hole beyond the reach of a person standing on the ground is to tie it to the curved handle of a walking stick, and hang the stick on the rim of the aperture.

**Chemical Analysis.**

The pH and Winkler tests were carried out in the field. For all other estimation the water was taken back to the laboratory; after standing for twenty-four hours the supernatant water without sediment was decanted off and tested. This was done in order to obtain one standard for all estimations.

The chemical factors considered were hydrogen ion concentration, dissolved oxygen, ammonia nitrogen, albuminoid nitrogen, total organic nitrogen, total volatile and fixed solids. Estimations were made by the standard methods of the American Public Health Association.

The carbon dioxide estimations were made by L. J. Howland, the author of Part II of this paper.

The hydrogen ion concentration (Tables I, II, III) of the three holes varied between 5·2 and 7·4, but the variation did not seem to have any effect on larval incidence. L. J. Howland also did a few pH estimations on different days. Her figures fell within the above limits. This is not in accordance with Macgregor's pH figures for tree-hole mosquitos. He stated that when the tree-hole water, the hydrogen ion concentration of which was higher than pH 4·4, became less acid, the tree-hole mosquitos were unable to survive.

Dissolved oxygen estimated by the permanganate modification of the Winkler test was found to be absent. It is now believed that the Winkler test is not reliable for minute traces of dissolved oxygen. The high organic content of the water, and the fact that the oxygen of strong solutions of permanganate was rapidly absorbed, led one to believe that the dissolved oxygen must be present in very small quantities if at all.

Chlorides were present in quantities of 0·75 to 1·30 parts per 100,000. They are not referred to in the tables as the variation was so little, and as it is probable that such small quantities have no biological significance.

The results of the analysis of the other factors are given in Tables I, II and III.

Monthly means derived from all readings on all three trees are graphed (figs. 1, 2, 3). These, however, are not very good, as the monthly estimations were so few and irregular. The graphs of larval incidence refer to *Anopheles plumbeus*, as it was most abundant in the three rot-holes. In fig. 1, the monthly mean temperature for all three holes is graphed. The rainfall, monthly total, is graphed in fig. 2. The rainfall was measured at Farnham House, about two miles distant from Burnham Beeches.

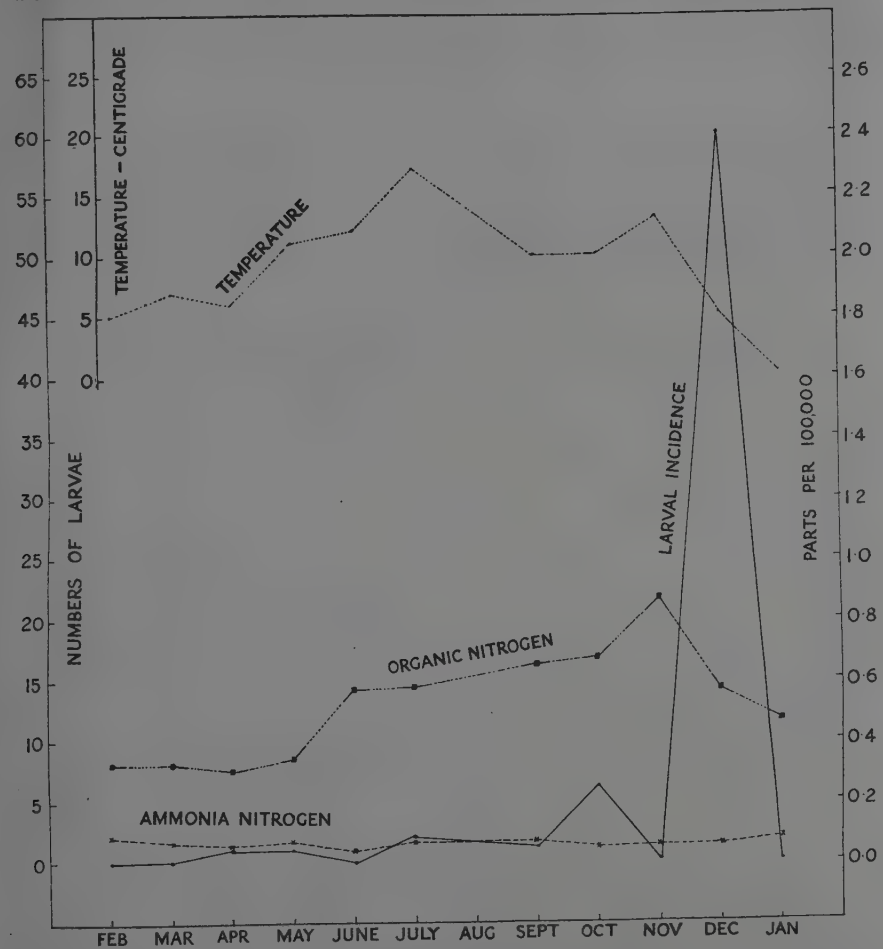



Fig. 1. Tree-hole 1: monthly means; also temperature for all three tree-holes.

**Nitrogen.**

Three nitrogen estimations were made—ammonia nitrogen, albuminoid nitrogen and total organic nitrogen.

The ammonia nitrogen figures (Tables I, II, III) do not show much variation. Between 0·03 and 0·11 parts per 100,000 they do not appear to have any effect on the larval incidence. In tree-hole 3 when the ammonia nitrogen figure rose to

0·82 parts per 100,000 a few small dead larvae were found. This was in July. In September and October larvae were abundant, but in November when the ammonia nitrogen figure rose to 0·20 parts per 100,000 no larvae were found. Very little significance can however be attached to the latter observation, as larvae may have been swept out of the hole when the water overflowed on 31st October.

It is now realised that the albuminoid nitrogen figure gives only a rough index of the organic matter in solution. Therefore in future estimations I think it should be omitted in favour of the Kjeldahl estimation for total organic nitrogen. This gives a much better and more stable figure.

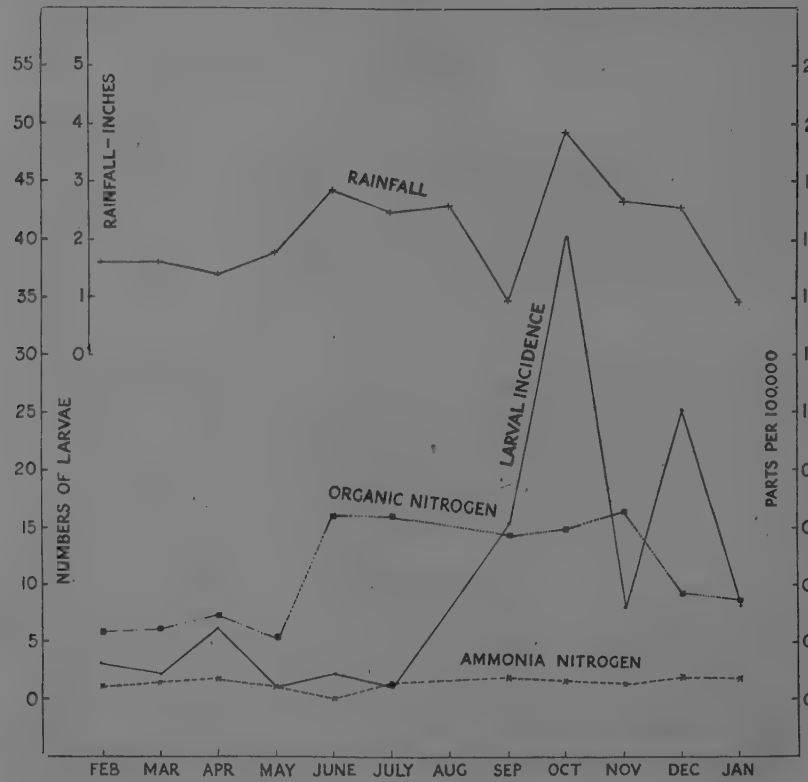



Fig. 2. Tree-hole 2 : monthly means ; also monthly total rainfall.

The total organic nitrogen figures (Tables I, II, III) show distinctly more variation than those of ammonia nitrogen. The figures were highest and the variation greatest in tree-hole 3. In all three holes the figures were lowest at the beginning of the year from February to May. In June there was a distinct rise, which was maintained until November, then a fall in December and January. The limits of toleration of total organic nitrogen appear to lie between 0·21 and 1·60 parts per 100,000.

Inorganic nitrogen (nitrates and nitrites) was not estimated, but it is thought that this should be done in further investigations of this kind. Williamson (1927) attaches importance to the ratio between inorganic and ammonia nitrogen.

**Solids.**

The figures for total and fixed solids are given in Tables I, II and III. The difference gives the figure for volatile solids. The amount of solids was highest in hole 3. There does not appear to be any correlation with larval incidence.

**Carbon Dioxide.**

The results of the carbon dioxide estimations appear in Table IV. These estimations were done by Van Slyke's method. The figures are too few to show any definite evidence of the effects of carbon dioxide on larval incidence.

**Fauna.**

The mosquito fauna consisted of *Anopheles plumbeus*, *Finlaya geniculata* and *Orthopodomyia pulchripalpis*. The numbers collected are given in Tables I, II and III. The trees differed in fauna.

Tree-hole 2, which was richest in *Anopheles plumbeus*, was richest also in *Finlaya geniculata* and *Orthopodomyia pulchripalpis*. *Orthopodomyia* larvae were never found in tree-hole 3 and only on one occasion in tree-hole 1. Tree-hole 1 was the least productive; except in December the larvae collected from this hole were very few in number.

From the graphs (figs. 1, 2, 3) of larval incidence (*Anopheles plumbeus*) it will be noted that there is a maximum in the latter part of the year. The majority of

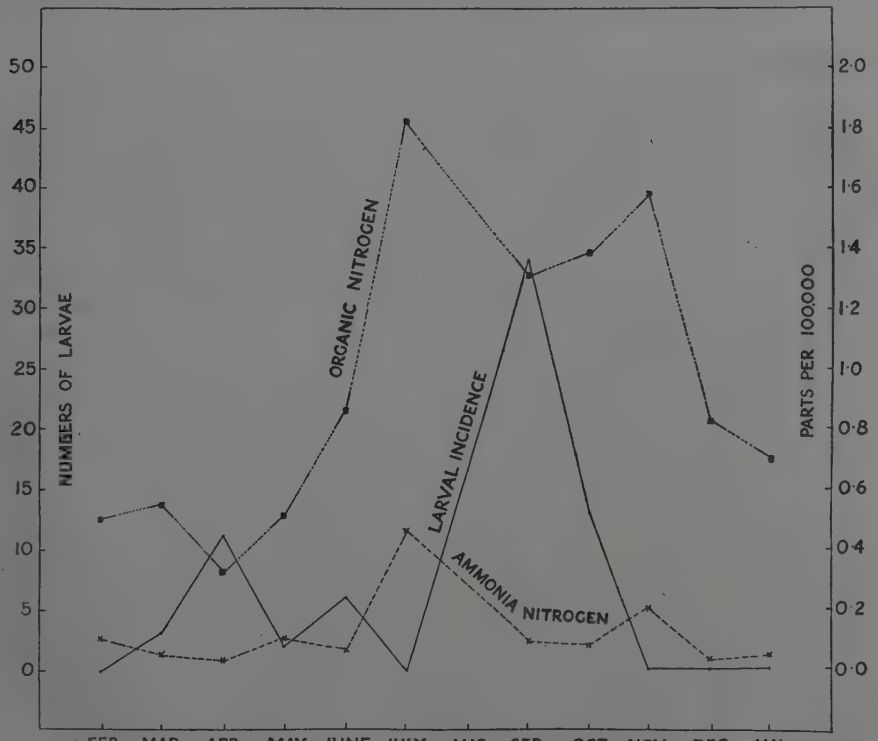



Fig. 3. Tree-hole 3: monthly means.

larvae found at this time were very small. For the rest of the year larvae taken in March and April were small. All larval stages were found during the summer months. Pupae were found only on two occasions in June and July. Thus the highest seasonal incidence for larvae of *Anopheles plumbeus* appears to be from September to December. From Table II the highest seasonal incidence of *Orthopodomyia pulchripalpis* occurs in September.

In addition to the mosquito fauna the following insects were collected from time to time :—

Chironomid larvae—*Metriocnemus martinii* (Thienemann).
Anthomyiid larvae—*Phaonia mirabilis* (Ringdahl).
Syrphid larvae—*Myiatropa florea*, L.
Coleopteron—*Helodes* sp.

These are the usual inhabitants of holes in beech trees.

The presence of Chironomid larvae in a medium in which dissolved oxygen could not be demonstrated is interesting, as these larvae have haemoglobin in their blood ; for this reason dissolved oxygen would appear to be essential. It is however stated that they live quite well in such a medium. Cole (1921) says they probably get their oxygen from vegetable debris in the water by means of an enzyme complex, which can build up a peroxide, and a peroxidase which splits off the oxygen required by the haemoglobin. These larvae however require very minute quantities of oxygen. The possibility of the presence in such waters of small quantities of oxygen not measurable by the Winkler test must be remembered.

## Discussion.

Attention was first drawn to the importance of chemical factors in mosquito ecology by Macgregor (1921) in his study of the correlation between hydrogen ion concentration and mosquito prevalency. Buxton & Hopkins (1924) went a step further when they showed that water vapour by itself was not highly attractive to the female *Aëdes argenteus*, but that water to which various organic substances had been added obtained many more layings and eggs. If their experiments were repeated and the waters analysed, valuable data would result. Senior White (1927) in India has shown that ammonia nitrogen in certain quantities inhibits certain species of *Anopheles*. Williamson (1927), as a result of his work in Malaya, attaches importance to what he terms the ' nitrification ratio ' (*i.e.*, the relation between inorganic and ammonia nitrogen). This, he points out, serves only in shallow water where mixing is continuous and practically perfect.

As regards tree-hole water, no data up to the present time have been collected over a sufficiently long period to be of value. Ramsden (1920) made a chemical analysis of two tree-hole waters, the one breeding mosquitos, the other not. He found the waters to be of similar physico-chemical content. His estimations do not prove anything, as they were not repeated. Karstens' (1927) estimations of the rot-hole waters from ash trees are also too few to be of value.

In the present investigation it will be seen from Tables I, II and III, and figures 1, 2 and 3, that all three tree-holes are attractive to *Anopheles plumbeus*. The greatest larval incidence occurs from September to December. *Anopheles plumbeus* is practically never found breeding in any place other than tree-holes. We may conclude, therefore, that tree-hole water is attractive to this mosquito and that it is most attractive in late summer and early autumn. We have then to consider the possible factors that aid the female mosquito in her choice of this place in which to lay her eggs. Physical factors alone appear to be insufficient. The pH is not significant. Certain other chemical factors can be discarded : dissolved oxygen is negligible ; chlorides can be eliminated. There is no correlation between the amount of solids present and the larval incidence. The ammonia nitrogen apparently has

no effect, but the total organic nitrogen shows more variation and presents an interesting problem. An increase in the total organic nitrogen content occurs in June; this increase is maintained until November, and falls again in December and January. This rise and fall appears to be dependent on temperature. The temperature may attain a certain point at which it is more favourable to the production of organic nitrogen in solution; this would be due to the action of bacteria on leaves etc. in the water. From the graphs 10° Centigrade appears to be such a temperature. This must be of great importance in the economy of the rot-hole. It is possible that this increase in total organic nitrogen plays a big part in attracting the female mosquito. It is significant that she lays many more eggs when this increase has been established. Obviously the total organic nitrogen is important and is certainly a substance which must be studied in future work.

The drawback to such an investigation as this in this country is the variation in climatic factors. One year's data cannot be taken as a standard. The facts, however, form a useful basis for further work either in this or in some other country.

## Summary.

1. The water of three rot-holes, rich in organic matter, contained *Anopheles plumbeus* larvae at all times throughout the year. The highest larval incidence occurred from September to December.

2. No correlation was found between hydrogen ion concentration, dissolved oxygen, chlorides, solids, ammonia nitrogen, and larval incidence.

3. Total organic nitrogen was thought to be an important factor in the life of the rot-hole. It was considered that this factor aided the female mosquito in her choice of this place in which to lay her eggs.

I am indebted to Dr. P. A. Buxton for his interest in this work and for two photographs of tree-holes; to Dr. E. M. Delafield, who enabled me to have my analysis checked in the University College Public Health Chemistry Department from time to time; to Mr. F. W. Edwards for help in identification of species; and to Mr. J. T. Saunders, Cambridge, for helpful suggestions throughout the course of this investigation.

TABLE I.

*Tree-Hole* 1.

| Date. | Temp. (Cent.) | pH. | Nitrogen. | | | Solids. | | Mosquitos. | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Amm. N. | Alb.N. (Parts p | Org. N. er 100,000.) | T.S. | F.S. | A. | F. | O. |
| Feb. 20 ... | 5 | 6·7 | 0·08 | 0·18 | 0·32 | 72 | — | — | — | — |
| Mar. 26 ... | 10·5 | 6·8 | 0·06 | 0·11 | 0·325 | 160 | 80 | — | — | — |
| Apr. 23 ... | 6 | 6·8 | 0·05 | 0·09 | 0·295 | 120 | 50 | 1 | — | — |
| May 29 ... | 14 | 6·8 | 0·06 | 0·16 | 0·34 | 130 | 60 | 1 | — | — |
| June 18 ... | 12 | 7·2 | 0·03 | 0·36 | 0·57 | 120 | 30 | — | — | — |
| July 5 ... | 17 | 6·7 | 0·05 | 0·255 | 0·54 | 70 | 20 | 1 | — | — |
| ,, 16 ... | 16 | 7·2 | 0·03 | 0·36 | 0·57 | 105 | 10 | 2 | 2 | — |
| ,, 23 ... | 18 | 7·2 | 0·10 | 0·38 | 0·60 | 120 | 20 | 3 | 2 | — |
| Sept. 10 ... | 11 | 6·8 | 0·08 | 0·41 | 0·62 | 160 | 45 | — | — | — |
| ,, 24 ... | 9 | 7·2 | 0·05 | 0·37 | 0·67 | 170 | 32 | 2 | — | — |
| Oct. 10 ... | 13 | 7·0 | 0·05 | 0·34 | 0·85 | 185 | 40 | 10 | — | — |
| ,, 31 ... | 7 | 7·0 | 0·03 | 0·18 | 0·48 | 91 | 35 | 2 | — | — |
| Nov. 14 ... | 13 | 7·1 | 0·05 | 0·38 | 0·86 | 95 | 40 | — | — | — |
| Dec. 4 ... | 5 | 6·9 | 0·05 | 0·29 | 0·56 | 118 | 40 | 60 | — | 1 |
| Jan. 7 ... | 0·2 | 6·8 | 0·07 | 0·24 | 0·46 | 95 | 40 | — | — | — |

A—*Anopheles plumbeus*, F—*Finlaya geniculata*, O—*Orthopodomyia pulchripalpis*.

TABLE II.

*Tree-Hole 2.*

| Date. | Temp. (Cent.) | pH. | Nitrogen. | | | Solids. | | Mosquitos. | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Amm.N. | Alb.N. (Parts p | Org.N. er 100,000.) | T.S. | F.S. | A. | F. | O. |
| Feb. 6 ... | 4 | 6·5 | 0·045 | 0·16 | — | — | — | 4 | 3 | 4 |
| ,, 13 ... | 6 | 6·7 | 0·04 | 0·08 | 0·23 | 65 | — | 2 | 2 | 3 |
| Mar. 12 ... | 1 | 6·5 | 0·055 | 0·08 | 0·24 | 178 | — | 2 | 3 | 3 |
| Apr. 2 ... | 9 | 6·5 | 0·07 | 0·08 | 0·29 | 120 | 60 | 6 | 4 | — |
| May 22 ... | 9 | 6·7 | 0·04 | 0·085 | 0·21 | 60 | 20 | 1 | 3 | 1 |
| June 18 ... | 12 | 6·7 | 0·075 | 0·30 | 0·64 | 100 | 30 | — | 1 | 3 |
| July 5 ... | 17 | 6·9 | 0·075 | 0·38 | 0·66 | 116 | 30 | — | 2 | 3 |
| ,, 16 ... | 16 | 7·2 | 0·03 | 0·40 | 0·61 | 90 | 20 | — | 8 | 2 |
| ,, 23 ... | 18 | 7·0 | 0·05 | 0·41 | 0·62 | 100 | 20 | 3 | 2 | — |
| Sept. 10 ... | 11 | 6·8 | 0·08 | 0·24 | 0·40 | 95 | 30 | 5 | 1 | — |
| ,, 24 ... | 9 | 7·0 | 0·05 | 0·39 | 0·75 | 136 | 26 | 25 | 2 | 16 |
| Oct. 10 ... | 13 | 7·0 | 0·09 | 0·34 | 0·79 | 119 | 20 | 60 | — | 50 |
| ,, 31 ... | 7 | 6·8 | 0·03 | 0·11 | 0·40 | 73 | 20 | 20 | — | — |
| Nov. 14 ... | 13 | 6·8 | 0·05 | 0·21 | 0·65 | 80 | 20 | 8 | — | — |
| Dec. 4 ... | 5 | 6·9 | 0·07 | 0·16 | 0·36 | 103 | 28 | 25 | 1 | 1 |
| Jan. 7 ... | 0·2 | 6·8 | 0·07 | 0·15 | 0·34 | 100 | 30 | 8 | — | 1 |

TABLE III.

*Tree-Hole 3.*

| Date. | Temp. (Cent.) | pH. | Nitrogen. | | | Solids. | | Mosquitos. | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Amm.N. | Alb.N. (Parts p | Org.N. er 100,000.) | T.S. | F.S. | A. | F. | O. |
| Feb. 20 ... | 5·5 | 7·5 | 0·10 | 0·29 | 0·50 | 176 | — | — | — | — |
| Mar. 6 ... | 7·0 | 7·2 | 0·03 | 0·27 | 0·628 | 170 | — | 2 | 3 | — |
| ,, 19 ... | 9·5 | 7·1 | 0·07 | 0·14 | 0·47 | 200 | — | 4 | 1 | — |
| Apr. 16 ... | 4·0 | 7·3 | 0·03 | 0·15 | 0·32 | 180 | 130 | 11 | 4 | — |
| May 22 ... | 10·0 | 7·0 | 0·11 | 0·32 | 0·51 | 160 | 80 | 2 | 1 | — |
| June 18 ... | 12·0 | 7·0 | 0·065 | 0·44 | 0·865 | 220 | 120 | 6 | — | — |
| July 9 ... | 17·0 | 5·2 | 0·09 | 0·48 | 0·86 | 180 | 85 | — | — | — |
| ,, 16 ... | 16·0 | 6·4 | 0·82 | 1·76 | 2·78 | 345 | 120 | 10 | dead lar | vae |
| ,, 23 ... | dry | dry | dry | dry | dry | dry | dry | | dry | |
| Sept. 10 ... | 11·5 | 7·3 | 0·07 | 0·51 | 1·10 | 212·5 | 90 | 5 | — | — |
| ,, 24 ... | 9·5 | 7·1 | 0·11 | 0·64 | 1·60 | 190 | 60 | 63 | 13 | — |
| Oct. 10 ... | 13·5 | 7·0 | 0·10 | 0·48 | 1·48 | 186 | 62 | 25 | 2 | — |
| ,, 31 ... | 8·0 | 7·2 | 0·06 | 0·43 | 1·28 | 182 | 59 | — | — | — |
| Nov. 14 ... | 13·5 | 7·2 | 0·20 | 0·56 | 1·58 | 224 | 100 | — | — | — |
| Dec. 4 ... | 5·5 | 7·4 | 0·03 | 0·40 | 0·82 | 155 | 41 | — | — | — |
| Jan. 7 ... | 0·2 | 7·2 | 0·05 | 0·31 | 0·70 | 152 | 45 | — | — | — |

TABLE IV.

*Carbon Dioxide.*

| Tree-hole 1. | | Tree-hole 2. | | Tree-hole 3. | |
|---|---|---|---|---|---|
| Date. | Cc. per litre. | Date. | Cc. per litre. | Date. | Cc. per litre. |
| Feb. ... | 102·6 | | | | |
| July 5 ... | 110 | July 5 ... | 56 | July 5 ... | 140 |
| ,, 16 ... | 160 | ,, 15 ... | 83 | | |
| ,, 23 ... | 127 | ,, 27 ... | 130 | | |
| Aug. 3 ... | 74 | Aug. 3 ... | 20 | | |
| ,, 31 ... | 150 | ,, 31 ... | 93 | Aug. 31 ... | 184 |
| Oct. 20 ... | 144 | Oct. 25 ... | 46 | Oct. 20 ... | 80 |
| ,, 19 ... | 148 | | | ,, 25 ... | 80 |

## Part II.

### *The Food of Mosquito Larvae in Tree-Holes.*

**Life-Forms in Tree-Holes.**

The investigations of the algal food of tree-hole larvae was performed as a part of a larger investigation of the food of British mosquito larvae in the ponds and trees in the region of Farnham Royal, Buckinghamshire.

The investigation of the food of the tree-hole larvae has been very disappointing from the algal point of view. Very few algae have been found in the tree-holes. It might have been expected that such forms as *Coccomyxa, Pleurococcus, Chlorella, Trebouxia, Chlorococcum*, diatoms (especially soil forms) and flagellate forms of a varied character, would occur fairly commonly. Some of these expectations were realised, but the algal flora was scanty. The general source of the algae was the slime covering the rotting beech leaves. The walls of the holes were very barren, *Pleurococcus* being the chief constituent, and this not in a fresh condition.

The largest quantities of algae appeared in tree-holes 1 and 2. As light penetrated these holes from the tops they formed a suitable locus for algal growth. The smaller growth in tree-hole 3, the entrance of which was open to the sun and a free circulation of air, was a matter for surprise, especially as the general physical conditions

Fig. 4. *Hantzschia amphioxys*, (Kütz) Grun. ×750.

of the first half of the year did not differ very much from those in the other tree-holes (*see* Part I). The amount of solids in this hole was higher, but on the whole this would be an advantage to the growth of the algae, as the amount was no greater than that found in many ponds.

The combined algal flora of the three tree-holes was as follows :—

Bacillariales.

*Eunotia lunaris*, Ehrenb.
*Melosira varians*, Agardh.
*Synedra ulna*, Ehrenb.
*Microneis hungarica*, Grun.
*Achnanthidium lanceolatum*, Breb.
*Gomphonema* sp.
*Hantzschia amphioxys* (Kütz), Grun. A soil form (fig. 4).
*Pinnularia viridis*, Ehrenb.

Chlorococcales.

*Chlorella vulgaris*, Beijer.

Chaetophorales.

*Pleurococcus Naegeli* Chod.

Flagellatae.

*Euglena quartana*, Moroff.
*Menoidium incurvum* (Fres), Klebs (fig. 5*a*).
*Astasia curvata* Klebs (fig. 5*b*).
*Trachelomonas hispida* (Perty), Stein.

FILAMENTOUS FORMS.

*Mougeotia* sp.
*Hormidium* sp.

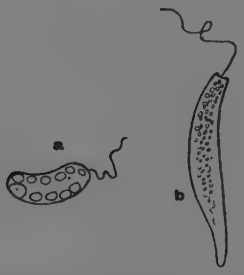



Fig. 5. *a, Menoidium incurvum* (Fres), Klebs ; *b, Astasia curvata*, Klebs. ×450.

Most of the diatoms are epiphytic or soil forms and have been found (except in the case of *Melosira*) in the neighbouring pools of Burnham Beeches. They could have been carried into the hole by the falling leaves. The Flagellatae are forms found in waters containing decaying vegetation, although *Trachelomonas hispida* is also a general inhabitant of ponds. None of the diatoms are interesting from the systematic point of view. West & Fritsch (pp. 335–385) give a general account of these forms.

The following table shows the forms which occurred in the separate tree-holes and in the alimentary canals of the three species of larvae :—

| *Algae.* | *Tree-holes.* | | | *Larvae.* | |
|---|---|---|---|---|---|
| | 1. | 2. | 3. | A. | F. | O. |
| Microneis ... ... ... | * | * | — | — | — | — |
| Achnanthidium ... ... | * | * | * | † | ‖ | — |
| Melosira ... ... ... ... | — | — | * | — | — | — |
| Pinnularia ... ... ... | — | * | * | — | — | — |
| Eunotia ... ... ... ... | * | * | — | — | — | — |
| Synedra ... ... ... ... | — | * | — | † | — | — |
| Hantzschia ... ... ... | — | * | — | — | — | — |
| Gomphonema ... ... ... | * | * | — | — | — | — |
| Hormidium ... ... ... | * | * | * | — | — | — |
| Mougeotia ... ... ... | * | * | * | — | — | — |
| Euglena ... ... ... ... | * | * | — | — | † | — |
| Astasia ... ... ... ... | * | — | — | — | ‖ | — |
| Menoidium ... ... ... | * | — | * | † | — | — |
| Chlorella ... ... ... ... | — | * | — | — | — | — |
| Pleurococcus ... ... ... | * | * | * | † ‖ | †‖‡ | † |
| Trachelomonas ... ... ... | — | * | — | — | — | — |

* denotes presence ; ‡ present in 1st hole ; † in 2nd hole ; ‖ in 3rd hole.
A, *Anopheles plumbeus* ; F, *Finlaya geniculata* ; O, *Orthopodomyia pulchripalpis*.

All these forms were scantily represented and were generally found on the beech leaves, not freely in the water. The diatoms occurred mostly in January. All the forms mentioned above, except *Melosira*, were represented in tree-hole 2.

*Microneis*, *Achnanthidium* and *Eunotia* were found in tree-hole 1. *Chlorella* and *Pleurococcus* were erratic in their appearance. They were probably washed down the sides of the hole or fell in from above.

All the Flagellatae were rare and were always found amongst the leaves. *Euglena quartana* and *Menoidium incurvum* were practically perennials and occurred in all three tree-holes. *Astasia* was found in tree-hole 2 on 2nd April, and in 1 on 19th October. It is quite probable that it was present in very small quantities before this and was overlooked. *Trachelomonas* occurred once in tree-hole 2.

The presence of *Melosira* is inexplicable, as it is a form which frequents waters on chalk soils with pH varying about 8 and has only been found in a very rare condition in one pond out of six investigated in the surrounding district.

Fig. 6. Shells of Rhizopoda. ×550.

As all these forms occurred so rarely no correlation could be established between their presence and absence, and the presence and absence of the larvae. The presence of diatoms in a tree-hole may occasion some surprise, but it should be remembered that they were always very rare.

Besides the larger fauna in the tree-hole, some microscopic animals were observed. No attempt has been made to identify the species, but the genera are as follows :—

Rotifers : *Metapidia, Philodina ;* Protozoa : various Rhizopoda, shells all empty (fig. 6), *Colpidium, Holophyra, Scyphidia, Actinophrys* ; a Nematode.

Like the diatoms, all these forms were found mainly amongst the leaves, with the exception of *Scyphidia*, which was found on *Finlaya*, especially on 23rd July, in tree-hole 1. *Scyphidia* was not found in tree-hole 3, but appeared in the other two holes in June and July, when the pH of the water was about 7. *Metapidia* also appeared when the pH was lowest (7·3) in tree-hole 1 and remained until October, but it was never plentiful. Various Rhizopod shells have been present, but in no case have any living contents been observed.

The algal or animal constituents were very few when compared with the vast amount of miscellaneous debris. The sediment in the tree-holes consisted of fragments of bark and of vessels ; mesophyll cells of beech leaves (sometimes with green contents); beech leaf epidermal cells and fragments of vascular bundles. Fungous spores of various shapes and sizes were present, but very few were germinating. Among these were found a few spines and scales from the wings of mosquitos and moths.

**Contents of Guts of Larvae.**

For method of collection see Part I. Immediately after collection the larvae were killed quickly by 20 per cent. formalin, washed and put in dilute iodine, which

kept them soft. The guts were removed and were examined individually. The contents of the guts of larvae of *Anopheles plumbeus* and *Finlaya geniculata* consisted mostly of the debris described above. The following summary shows approximately the type and the amount of algal and animal food found in the 126 larvae of these species which were dissected.

Food found in the larvae of 47 *Finlaya geniculata* : 59 *Pleurococcus*, 8 wing scales, 59 pollen grains, 2 animals, 26 mesophyll cells, 4 *Scyphidia*, and 4 *Menoidium*.

Food found in 79 larvae of *Anopheles plumbeus* : 14 diatoms (mostly empty), 2 colonies of bacteria, 2 animals, 369 *Pleurococcus*, 10 *Chlorella*, 20 mesophyll cells, 1 *Soredia*, 1 short filament of *Hormidium*, 1 *Trachelomonas*, 32 wing scales, 7 pollen grains, 4 green cells, and 1 *Menoidium*.

**Algal Food.**

There is little in these lists that appears worthy of comment except the scantiness of the algal food. Both species appear to ingest whatever algae are present, but these alone would not seem to form sufficient food. The comparatively large amount of *Pleurococcus* taken in by *Anopheles* on 6th April, when this alga was rather common on the surface of the water, is no doubt connected with the surface-feeding habit of *Anopheles*. In one larva as many as 86 cells were counted, the chloroplasts being in all stages of disintegration. The *Finlaya* contained less *Pleurococcus* than the *Anopheles*.

Twelve *Orthopodomyia pulchripalpis* were examined. Very few algal cells were found. The gut contents were much more finely divided than in the other two species.

The algae generally had their chloroplasts shrunken or absent. The diatoms were without chlorophyll. The cellulose walls of the algae were never found to be broken up. The condition of the chlorophyll does not suggest that these cells had been digested, as cells were found outside the gut also with their chloroplasts in these conditions.

**Animal and other Food.**

Not many remains of insects were found in the guts of *Anopheles plumbeus*. This does not accord with the observations recorded by Edwards and Christophers.

Twice during April and May an *Anopheles plumbeus* was found to contain part of some spiny animal with red granules (a Chironomid) ; and a Rotifer and the mastax of another were found in the gut of *Anopheles* on 27th September. On 23rd July the larvae of *Finlaya* were partly covered with *Scyphidia*, but very few of these were found in the gut. Scales from the wings of mosquitos or moths were generally found in the guts, but this could not be taken as evidence of animal food, as similar scales had been seen in the water.

An experiment was performed recently. Three *Anopheles* and four *Finlaya* which had been several days in a tube along with bits of *Calliphora* and a whole *Calliphora* were dissected. It was found that the guts of the *Anopheles* were almost empty except for a few cells of the yeast stage of a fungus, and the guts of *Finlaya* were packed with this fungus. There was no definite indication of *Calliphora* there in either case.

It is curious that no *Colpidia* were found in the larvae, although in the water they were sufficiently numerous to be ingested by the larvae and Barber reared *Anopheles* to maturity on them.

**Bacteria.**

No definite evidence has been found to suggest that bacteria are used as food. It is very interesting to note, however, that the water taken from the tree-holes remained "good" for a very long time. Thus it has been possible to keep three larvae of *Anopheles* in a closed bottle for over three months, the water never becoming foul.

Tree-hole 3, while drying up in June and July, contained many bacteria in the debris.

Bacteria have been seen in the guts of the larvae of *Orthopodomyia*.

**Conclusion.**

The foregoing facts point to the conclusion that the larvae are able to extract some nutriment from the debris and water in the tree-hole. It will be seen from the results obtained in Part I that the abundance of larvae is roughly proportional to the organic nitrogen content. This will partly depend upon the quantity of debris found in the hole, and it is possible that debris of such high nitrogen content is a suitable food.

**Summary.**

1. 138 larvae of *Anopheles*, *Finlaya* and *Orthopodomyia*, collected from three tree-holes described in Part I, were dissected and their contents examined.

2. Small algae, a few animals, bacteria and considerable quantities of rotting vegetation were found in them.

3. The algal and animal food seems to be insufficient for the anabolic processes of the larvae.

4. It is possible that bacteria may play some part in their nutrition, especially of *Orthopodomyia*.

5. It is also suggested that the larvae are able to utilise any food constituents present in the vegetable debris.

I wish to thank Dr. P. A. Buxton for the interest he has shown during the progress of this work, and Professor F. E. Fritsch for help in identification of the algal species.

*References.*

(1) American Public Health Association. Standard Methods of Water Analysis. 6th Ed. 1928.

(2) Barber, M. A. The Food of Anopheline Larvae.—Public Health Reports, U.S.A. Public Health Service, xlii, no. 22, June 1923.

(3) Buxton, P. A. & Hopkins, G. H. E. Researches in Polynesia and Melanesia. Parts I–IV.—No. 1 Memoir Series, London School Hyg. Trop. Med., 1927.

(4) Christophers, S. R. An Indian Tree-Hole Breeding *Anopheles*.—Ind. Jl. Med. Res. iii, p. 495, 1916.

(5) Cole, A. E. Oxygen Supply of certain Animals living in Water containing no Dissolved Oxygen.—Jl. Exper. Zool., xxxiii, p. 293, 1921.

(6) Edwards, F. W. Notes on Culicidae.—Bull. Ent. Res., vii, p. 201, 1917.

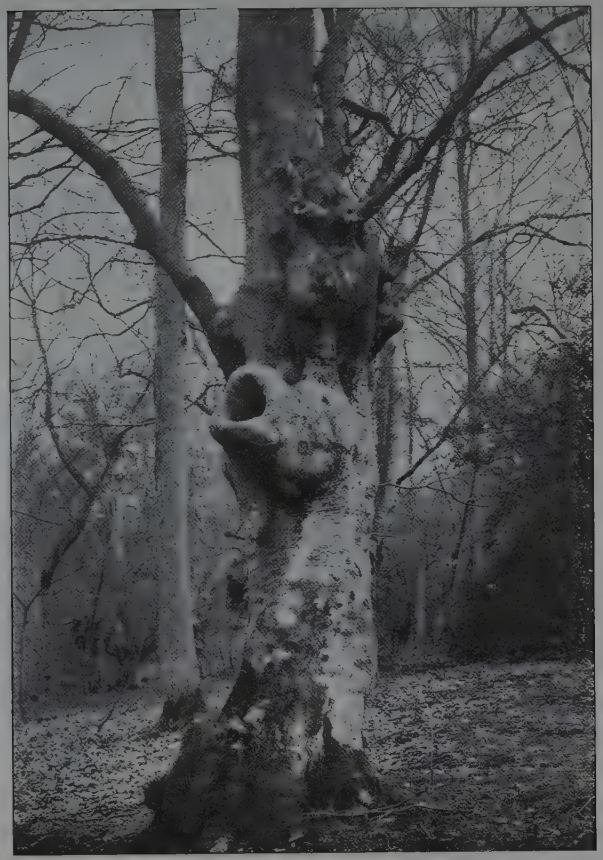
(7) Karstens, E. E. & Pavlovskii, E. N. Analysis of the Water taken from Hollows of the Ash (*Fraxinus excelsior*) and inhabited by Larvae of *Anopheles plumbeus*, Steph. (In Russian).—C.R. Acad. Sci. U.R.S.S., A., no. 18, pp. 293–295, 1927.

(8) MacGregor, M. E. The Influence of the Hydrogen Ion Concentration in the Development of Mosquito Larvae.—Parasitology, xiii, p. 348, 1921.

(9) RAMSDEN. Analysis of Tree-Hole Water.—Ann. Trop. Med. Parasit., xiii, p. 440, 1920.
(10) SENIOR WHITE, R. Physical Factors in Mosquito Ecology, Pt. II.—Ind. Jl. Med. Res., xvi, pt. 1, 1927.
(11) WEST, G. S. & FRITSCH, F. E. British Freshwater Algae. Cambridge Univers. Press.
(12) WILLIAMSON, K. B. Mosquito Breeding and Malaria in relation to the Nitrogen Cycle.—Bull. Ent. Res., xviii, pt. 4, 1927.

Tree hole 2. Burnham Beeches, Bucks. Breeding-place of *Anopheles plumbeus*, *Orthopodomyia pulchripalpis*, and *Finlaya geniculata*.

Tree hole 1. Burnham Beeches. Breeding-place of *Anopheles plumbeus*.



Tree hole 3. Burnham Beeches. Breeding-place of *A. plumbeus* and *Finlaya geniculata*.

# THE EARLY STAGES OF SOME WEST AFRICAN MOSQUITOS.

By V. B. Wigglesworth, M.A., B.Ch.,
*Department of Medical Entomology, London School of Hygiene and Tropical Medicine.*

A series of papers dealing with the early stages of West African mosquitos has been published in this journal by Wesché, Edwards, Macfie and Ingram between 1910 and 1923; but in a considerable number of species the early stages are still unknown. In the present paper descriptions are given of a few more of these. They formed part of a large collection got together during a tour in Nigeria and Sierra Leone lasting from February to August, 1928, made on behalf of the London School of Hygiene and Tropical Medicine.

The descriptions have been made on the same lines as those by Macfie & Ingram; but in describing the clypeal setae the nomenclature used by Edwards & Given (Bull. Ent. Res., xviii, pt. 4, 1926) has been adopted.

The author's acknowledgments are due to the Chief Secretary and the Director of Medical Services of Nigeria for providing transport throughout the Protectorate and much other assistance; to Dr. A. Connal, Director of the Medical Research Institute at Yaba, for kindly putting a bungalow and a laboratory at his disposal, and to Dr. R. M. Gordon for the generous assistance and hospitality which were enjoyed at the Sir A. L. Jones Research Laboratory of the Liverpool School of Tropical Medicine at Freetown. Finally, the author's thanks are due to Mr. F. W. Edwards, of the British Museum, who identified all the species, lent for description the larva of *Hodgesia malayi*, and very kindly looked over the descriptions in the present paper.

**Uranotaenia nigripes,** Theo. (fig. 1).

Larva.—Head dark in colour, about as broad as long. Antennae short, deeply pigmented, almost cylindrical; tuft in form of a minute seta a little beyond the middle. Bristles all short and situated at apex. Clypeal spines very small and blunt, arising from small prominences. Clypeal tufts: A a tuft of four or five simple hairs, B a rather slender simple hair, C a minute forked hair, *d* a relatively stout simple hair situated far forwards, *e* a slender simple hair. Thorax pale in front, more or less darkened behind, with well-developed dark chitinous tubercles at the bases of the tufts. Abdominal segments more or less pigmented dorsally except segment iv, which

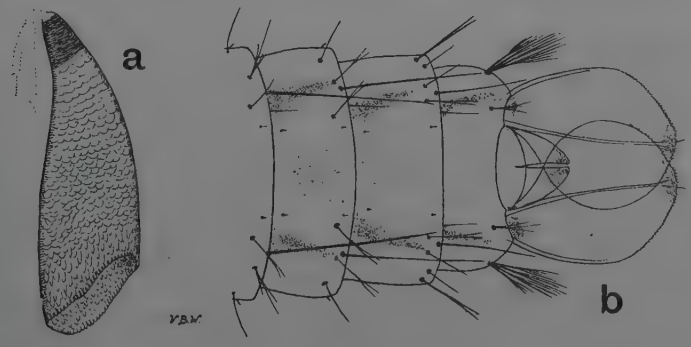



Fig. 1. *Uranotaenia nigripes*, Theo., pupa: *a*, trumpet; *b*, terminal segments of abdomen.

thus appears as a pale band. Lateral tufts of segments i and ii arising from dark chitinous tubercles. Setae on the other segments single. Comb consisting of about 14 spines with sharp points and delicate fringes set in the margin of the lateral plate. The uppermost lateral tuft of the eighth segment has three or four simple branches, the second tuft is a single hair arising from a chitinous tubercle in common with the last, the third a large tuft of about eight plumose hairs, the fourth a simple hair, and the fifth a stout two-branched hair below the comb. Anal segment strongly chitinised all over. Inner and outer dorsal hairs stout, long and simple. Lateral hair forked at base, strong and pubescent. Brush poorly developed, consisting of about four pairs of forked tufts. Siphon : index 4 ; almost cylindrical to tuft, which consists of about eight plumose branches situated just beyond the middle, then tapering somewhat to the tip. Pecten consisting of about twenty spines commencing some distance from base of siphon and ending opposite or beyond the tuft.

*Diagnosis.*—The structure of the larva appears identical in every detail with that of *U. inornata*, Theo. (Macfie & Ingram, Bull. Ent. Res., xiii, p. 415, 1923). In the figure given by these authors the clypeal spines are long and pointed. In a larva labelled as this species (the only one of the species which I have been able to examine) presented by Dr. Macfie to the London School of Hygiene and Tropical Medicine, these spines are short and blunt as in *U. nigripes*. The anal gills are not visible in any of my specimens (see Macfie & Ingram, *loc. cit.*). In the mounted specimen of *U. inornata* it cannot be determined whether the characteristic colour pattern of *U. nigripes* is present.

Pupa.—The pupa is very dark-coloured. Respiratory trumpets very dark, short, conical. Setae of cephalothorax small and simple. Paddles almost as broad as long ; midrib slender, ending in a minute seta ; outer buttress moderately developed ; margin of paddle with minute serrations towards tip. Lateral setae on segment viii consisting of five or six subplumose branches which divide towards the tip. Those on segment vii consist of a rather stout seta with two or three branches. Sublateral setae on segments iii, iv, v and vi very long and slender single hairs. Tufts on segment i well developed. A pair of small branched hairs on segment ii.

*Diagnosis.*—The pupa also is very similar to *U. inornata* but may be distinguished by the shape of the paddles, which are not triangular as in *U. inornata*, the small size of the apical seta on the paddles, and the greater development of the lateral seta of segment vii.

*Habitat.*—The larvae were plentiful in little rock pools along the stream " White water " above Freetown (vii. 1928), in company with *Anopheles smithii*, *Aëdes tarsalis* and *Culex decens*.

**Hodgesia sanguinis,** Theo. (figs. 2, 3).

Larva.—Described from a single fourth stage larval pelt. The true proportions of the head are not determinable. The cuticle is infuscated posteriorly. Antenna : shaft almost as long as the clypeus, of uniform thickness ; infuscated at base and apex, with short spines chiefly near the base ; tuft of about fifteen rather short simple hairs at nine-tenths ; preapical bristles very close to the tip, one short and stout, the other almost as long as the shaft of the antenna ; apical bristles stout and nearly equal to the shaft ; papilla very short. Clypeal spines long and stout. All the clypeal tufts consist of simple hairs : A with about six branches, B a long simple hair, C which lies almost directly behind B with about eight branches, *d* with three branches (very easily seen), and *e* a minute tuft of two or three branches. Mouth-brushes relatively large. Mentum rectangular with four teeth on either side of the large median tooth. Mouth-parts of normal structure. Thorax with relatively large tufts of slightly plumose hairs. The precise arrangement of the abdominal tufts cannot be determined. Comb consisting of seven teeth, largest above, each with a

delicate fringe of hairs ; no plate. Anal segment completely ringed with the plate, which shows a scale-like development of the chitin ; a single stout lateral hair near the posterior margin and a single row of five simple ventral hairs. Inner and outer dorsal hairs with multiple flattened branches. Ventral brush fairly well-developed ; there is a double row of hairs, three in each row, and each consisting of three or four simple branches. No barred area. Siphon cylindrical throughout, of equal length with the anal segment and of similar texture ; index nearly 2. The posterior lateral valve flaps relatively large—one-third the length of the siphon—but normal in structure. Pecten composed of six stout simple spines extending a little more than half the length of the siphon. The tuft is inserted close to the base and consists of about eight simple branches three-quarters of the length of the siphon.

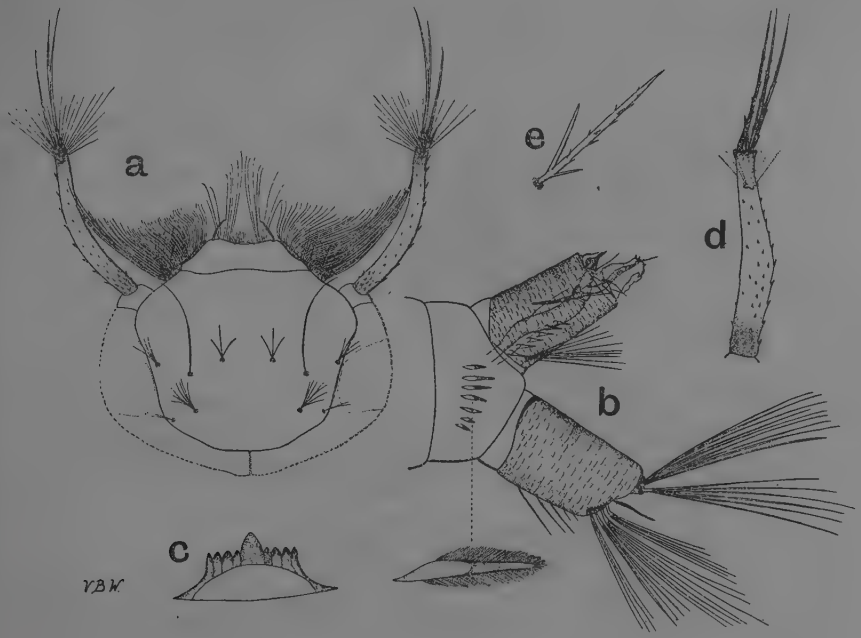



Fig. 2. *Hodgesia sanguinis*, Theo., larva : *a*, head ; *b*, terminal segments of abdomen ; *c*, mental plate.
*H. malayi*, Leic. : *d*, antenna of larva ; *e*, lateral tuft of anal segment.

Pupa.—Cephalothorax more or less infuscated all over. Respiratory trumpets small and of highly characteristic structure, being cleft almost to the base in the form of two leaflets. Outer leaflet four times as long as its average width, with more or less longitudinal strigulae and with numerous minute scale-like denticles on the outer surface. Inner leaflet only half the width of the outer and with a bifid tip ; it has the same longitudinal or oblique strigulation, but is without the minute denticles of the outer leaflet ; its anterior margin and tip are clothed with fine hairs and the posterior margin is reflected inwards away from the outer leaflet. Abdomen considerably infuscated, especially on segments v, vi, and vii. Paddles about one-quarter the length of the abdomen, pyriform, infuscated towards the tip ; the apex of the paddle is notched and the margin of the apical third bears a double row of

minute teeth. Midrib well developed, bearing a small forked seta at its extremity, and the outer buttress moderately strong. The dorsal setae are indicated in fig. 3. Tuft on segment i well developed and highly branched. All the other setae are inconspicuous; not even on segment vii or viii are there any well developed tufts.

*Habitat.*—The single larva was taken in March 1928 in a little shady pool, one of the dry season residual pools of an extensive swamp at Yaba (Lagos). It pupated almost at once and no peculiarity in its behaviour was observed.

Unfortunately, in the pressure of other work, the pupa was not carefully examined in the living state, so that the mode of action of the peculiar respiratory trumpets is not known; but one would suppose that the leaflets are drawn widely apart by the surface tension of the water, like the valves on the siphon of a Culicine larva.*

On the characters of the adult mosquito, *Hodgesia* is placed by Edwards (Ind. Jl. Med. Res. x, p. 248, 1922) among the Sabethine group of genera. The larval

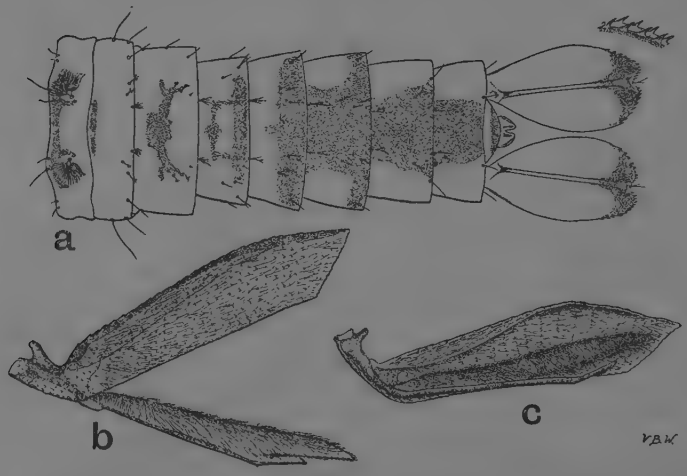



Fig. 3. *Hodgesia sanguinis*, Theo., pupa: *a*, dorsal view of abdomen; *b*, left trumpet seen from outside, leaflets separated; *c*, right trumpet seen from inside, leaflets opposed.

structure, however, does not at all suggest Sabethine affinities. It lacks the scattered hairs on the siphon and it has a well developed ventral brush. Its general characters are like those of *Aëdes*, the distinguishing features being the distal position of the antennal tuft, the basal situation (as in *Theobaldia*) of the tuft of the siphon, and the relatively large size of the posterior valve flaps. The median ventral hairs on the anal segment appear to be unique, although small tufts are present in this position in some *Aëdes* larvae. There is nothing in the structure of the larva which suggests an unusual mode of life. The remarkable form of the respiratory trumpets is diagnostic of the pupa. The small development of the lateral tufts on segments vii and viii is also unusual but does occur in some other pupae (e.g., *Megarhinus brevipalpis* and *Ficalbia malfeyti*).

* Since the foregoing description was made, a pupa of a *Hodgesia* sp. has been received by the British Museum from Dr. J. Schwetz in the Belgian Congo. The structure of this pupa agrees in all details with that given above.

**Hodgesia malayi,** Leic. (fig. 2, *d*, *e*.).

LARVA.—The larva of this species is very similar to that of *H. sanguinis* in most of the details of its structure, but differs as follows: Antenna with tuft at five-sixths (tuft itself missing from the specimen); apical bristles with numerous short spines. Clypeal tufts (including the characteristic form of B) very similar to those of *H. sanguinis*. Mentum as in *H. sanguinis*. Comb on the eighth abdominal segment with about seven teeth, each with a terminal spine and with a fringe of more delicate spines. The anal segment bears a lateral tuft near the posterior margin with two or three stout branches, one at least of which is spinose like the apical bristles of the antenna. Siphon tuft consisting of about eight rather stout branches and of equal length with the siphon.

This brief description is based on a single larval pelt in the collection of the British Museum, labelled "Colombo, Ceylon. 1913. S. P. James ? *Hodgesia malayi*." There was some doubt as to whether this might not be the larva of a *Ficalbia*, but the structure is so similar to that of *Hodgesia sanguinis* that its association with *H. malayi* is undoubtedly correct.

**Aëdes (Banksinella) punctocostalis,** Theo. (fig. 4).

LARVA.—The living larva has a very characteristic banded colour pattern. Head black, thorax orange, abdominal segments i, ii, iii, v and vi black, iv, vii and

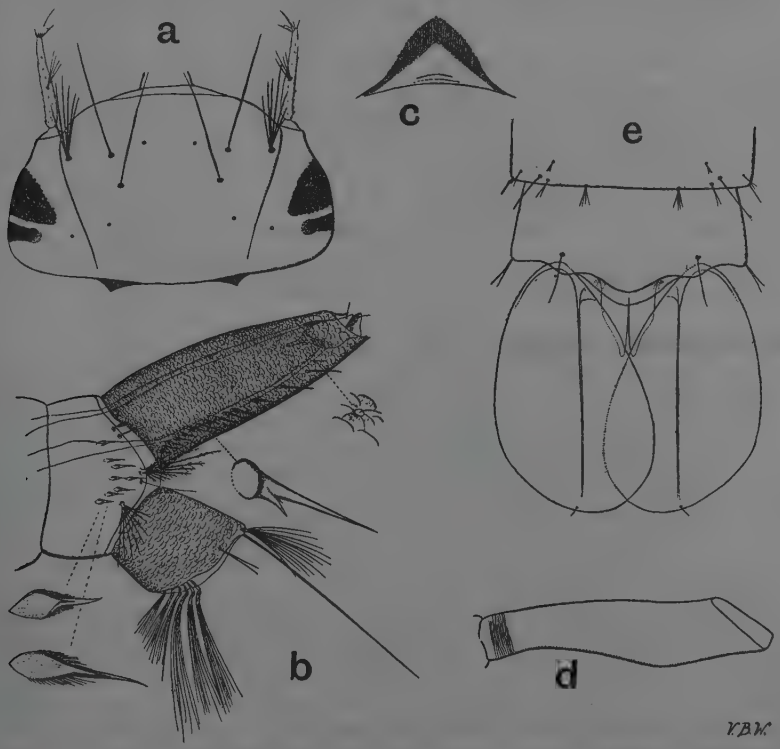



Fig. 4. *Aëdes* (*Banksinella*) *punctocostalis*, Theo., larva and pupa: *a*, head; *b*, terminal segments of abdomen of larva; *c*, mental plate; *d*, trumpet; *e*, terminal segments of abdomen of pupa, dorsal view.

viii orange. Siphon dark, becoming paler at the tip. Head twice as broad as long, very dark in colour. Antennae half the length of the head, tapering but slightly and pale in colour, covered with numerous small spines chiefly towards the base. Antennal tuft small, consisting of three or four simple branches, situated just before the middle. Subapical and apical bristles small. Clypeal spines pale and inconspicuous. Clypeal tufts: A a tuft of five or six simple branches, B and C rather stout and long simple hairs (*d* and *e* broken in both specimens). Mentum triangular with about forty small subequal teeth. Thorax: the lateral tufts of moderate size, those of the meso- and metathorax with well developed spines at the base. Abdomen: the colouring has been described above. Tufts mostly very small and inconspicuous. Eighth segment with two conspicuous flattened tufts of slightly plumose hairs. The comb is a patch of about eight sharply pointed scales delicately fringed. Anal segment strongly chitinised all over. Inner dorsal hair a tuft with simple branches, outer dorsal hair long, stout and simple; lateral hair small, with three or four branches. Brush with about six pairs of many-branched tufts. Siphon: index about 3; tapering slightly beyond the middle. Pecten of about fifteen strong teeth, each with a second denticle arising at its base. The pecten extends three-quarters the length of the siphon, the two terminal teeth being more widely spaced. The tuft is a very minute branched or simple hair situated just beyond the pecten.

*Diagnosis.*—The coloration of this larva is unique among the *Aëdes* larvae known from Africa. It is, however, not unlike the colouring of *Uranotaenia nigripes* described above.

Pupa.—Generally pale in colour, with some infuscation of the wing-cases. Respiratory trumpets dark, of moderate length; the spiral thickening present only at the extreme base; orifice at 45° with axis of trumpet. Tuft on first abdominal segment rather poorly developed. Sublateral seta on segment ii a simple flattened hair. Lateral seta on segment viii a rather delicate seta branched at the tip; the inner seta on this segment a rather stout simple hair. Paddles half as broad as long, unpigmented, with both the midrib (which ends in a minute seta) and the outer buttress poorly developed and with the margin minutely toothed.

*Habitat.*—Yaba, Lagos, iii. 28. The larvae were taken in a shady pool during the dry season, one of the residual pools of an extensive swamp.

**Aëdes (Aëdimorphus) abnormalis,** Theo. (fig. 5).

Larva.—Large in size and pale in colour. Head triangular in outline. Antenna colourless throughout, long (longer than the head) and slender, tapering slightly to the tip. The tuft, consisting of five or six slightly plumose hairs, lies at two-thirds of the shaft. All bristles terminally placed, rather long (one-sixth of shaft). Papilla on a cylinder of chitin as long as the diameter of the shaft. Clypeal spines long and slender. Clypeal tufts: A a small tuft of five or six subplumose hairs, B and C larger, approximated, each with three subplumose branches, *d* a minute tuft in transverse line with C, *e* a small tuft with two subplumose branches. Mentum triangular with about twelve teeth on either side, becoming larger and more widely spaced laterally. Thorax: tufts relatively small. Lateral tufts of meso- and metathorax with small pale spines at the base. The other larger tufts arise from small chitinous plates. Abdomen: tufts on most segments small and inconspicuous; those on eighth segment larger: the uppermost with many plumose branches, the second (arising from a chitinous plate in common with the last) of many simple branches; the third a small multiple tuft; the fourth with two rather long simple branches, and the fifth a tuft of about six plumose hairs. The comb consists of a patch of about thirty broad, obtuse, strongly fringed scales. Siphon pale except for a dark, very narrow, basal ring; of average length: index 3. The pecten consists of about two dozen sharply pointed teeth, darkened apically, each with three or four

blunt serrations on the lower margin. The pecten extends nearly half-way along the siphon, the two uppermost teeth being more widely spaced and devoid of serrations. Tuft small and arising near the apex of the siphon. Anal segment fairly well chitinised on the dorsum and sides; it is pale in colour, with a narrow dark basal ring. Towards the hind end the surface bears numerous small teeth, best developed

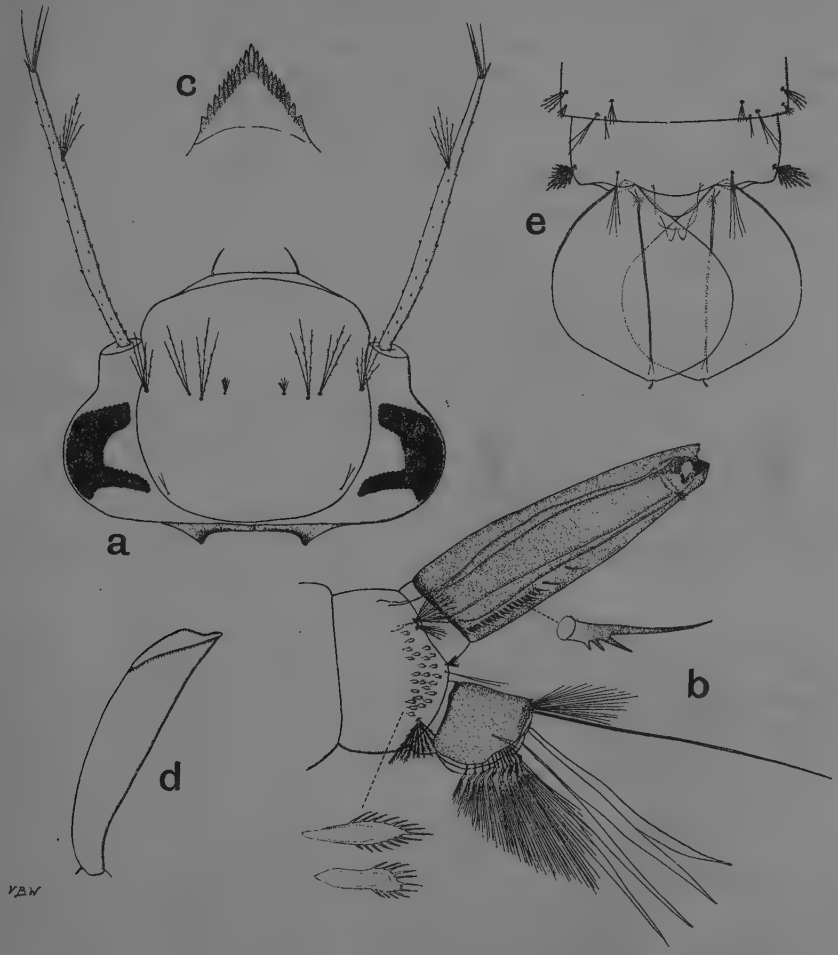



Fig. 5. *Aëdes* (*Aëdimorphus*) *abnormalis*, Theo., larva and pupa: *a*, head; *b*, terminal segments of abdomen of larva; *c*, mental plate; *d*, trumpet; *e*, terminal segments of abdomen of pupa, dorsal view.

dorsally. The inner dorsal hair forms a strong tuft of many branches, the outer dorsal hair single and stout. The lateral hair is a delicate tuft of three or four branches at one-third from the hind margin. Ventral brush and transverse bars well developed; the former of about six pairs of strong tufts of simple hairs. Anal gills very long (four times the anal segment) and acute.

*Diagnosis.*—*A. abnormalis* may be distinguished from all known African *Aëdes* larvae by the long slender antennae, which are longer than the head.

Pupa.—Large and pale, mottled with darker pigment on the dorsum and wing-cases of the cephalothorax and the second, third and fourth abdominal segments. The respiratory trumpets of average length and almost uniform diameter, slightly darkened near the orifice. Tuft on first abdominal segment fairly well developed, composed of dendritic hairs. Sublateral tufts of segments iv, v and vi composed of two long simple hairs. Lateral tufts on segment viii with about ten plumose branches and on segment vii with four plumose branches. Other tufts small. Paddles equal in length to their greatest breadth, colourless ; margin without teeth ; midrib and outer buttress distinct but narrow, the former with a minute terminal seta.

*Habitat.*—Sapele, S. Nigeria, vi. 1928, in a shady roadside puddle in a rubber plantation.

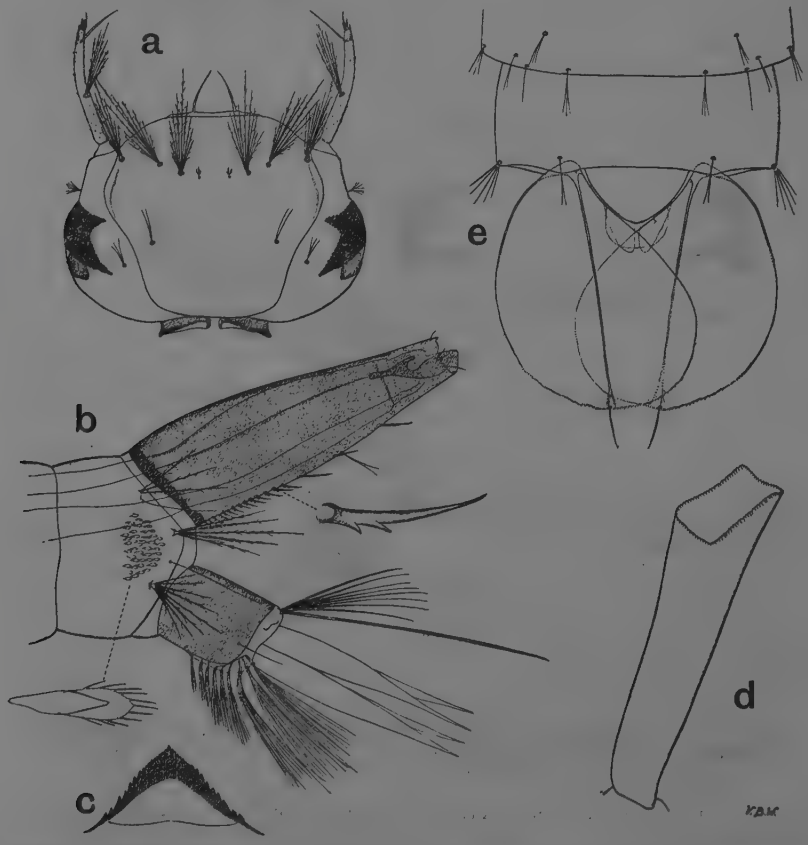



Fig. 6. *Aëdes* (*Aëdimorphus*) *tarsalis*, Newst., larva and pupa : *a*, head ; *b*, terminal segments of abdomen of larva ; *c*, mental plate ; *d*, trumpet ; *e*, terminal segments of pupa, dorsal view.

**Aëdes (Aëdimorphus) tarsalis,** Newst. (fig. 6).

Larva.—Head considerably broader than its length; the antennae slender, curved, with rather sparse spicules and with a tuft of about six subplumose hairs in the middle. Subterminal bristles just before the tip, one very small, the other long, curved and somewhat stout. Terminal bristles and papilla small. Clypeal spines long and slender. Clypeal tufts: A, B and C well developed tufts of subplumose hairs, *d* a minute branched tuft in a transverse line with C, *e* a long slender two-branched hair. Mental plate with a small median tooth and about twenty subequal teeth on either side. Thorax with plumes poorly developed; ventral tufts of meso- and metathorax with small basal spines. Abdomen with tufts inconspicuous; those on the eighth segment consist of a subplumose tuft uppermost, followed by a simple hair, then a subplumose tuft, a simple hair and a third subplumose tuft. The comb consists of forty to fifty scales with rounded tips, delicately fringed all round the margin. Siphon of average length, tapering markedly from before the middle; index nearly 4. The pecten consists of about fifteen slender, curved, slightly serrated spines set close together in the basal third, followed by two or three spines widely spaced, the last being at about two-thirds. The tuft is a long, slender hair with two or three branches placed a little beyond the middle. Anal segment well chitinised but not entirely ringed by the plate. Inner dorsal hair a well developed tuft of about ten simple branches, outer dorsal hair long and single. Lateral tuft a slender simple hair near posterior margin. Ventral brush consisting of about four pairs of branched tufts on the barred area and four small median tufts in front of this. Anal gills sharply pointed, two-and-a half times as long as the anal segment.

Pupa.—Cephalothorax somewhat infuscated dorsally. Respiratory trumpets rather short, conical, with orifice at about 45° to shaft. Abdomen: sublateral setae on segments iv, v and vi two-branched and long. Lateral seta on vii and viii in the form of small tufts. Paddles broad (two-thirds of length) very finely toothed in apical half, with midrib distinct though slender, ending in a rather long slender seta.

**Ficalbia malfeyti,** Newst. (fig. 7).

Larva.—The larva was figured by Edwards (Bull. Ent. Res. iii, p. 384, 1912) from a badly damaged specimen. Comparison with a good specimen shows that this figure is accurate in all particulars, including the external position of the antennal tuft.

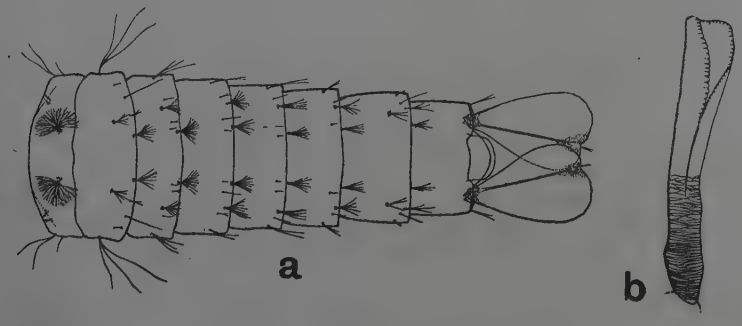



Fig. 7. *Ficalbia malfeyti*, Newst., larva: *a*, dorsal view of abdomen; *b*, trumpet.

Pupa.—Pale green in colour, with respiratory trumpets very dark and rather slender, with almost the basal half showing annular marking and with the opening very oblique and extending almost half-way down the trumpet. Abdomen with long several-branched lateral tufts on segments i and ii; all tufts on vii and viii small and inconspicuous. Paddles broad—almost as broad as long—slightly infuscated round the termination of the midrib; notched at the tip and with the margin of the apex delicately toothed. Midrib and external buttress very slender, the former ending in a minute forked seta.

**Summary.**

Descriptions are given of the larvae and pupae of *Uranotaenia nigripes*, Theo., *Hodgesia sanguinis*, Theo., *H. malayi*, Leic. (larva only), *Aëdes* (*Banksinella*) *punctocostalis*, Theo., *A.* (*Aëdimorphus*) *abnormalis*, Theo., *A.* (*A.*) *tarsalis*, Newst., and *Ficalbia malfeyti*, Newst.

*H. sanguinis* is remarkable chiefly for the structure of the respiratory trumpets of the pupa, each of which is cleft almost to the base in the form of two leaflets.

# ON SOME NEW AND INTERESTING THYSANOPTERA OF ECONOMIC IMPORTANCE.

By Richard S. Bagnall.

The following new genera and species are described :—

*Sericothripoides*, gen. nov.

*Brachyurothrips hargreavesi*, sp. n.

*Zeugmatothripoides africanus*, gen. et sp. n.

*Hoplandrothrips hystrix*, sp. n., and *H. coffeae*, sp. n.

*Brachyurothrips hargreavesi* is of interest as the material has enabled me to characterise clearly the genus *Brachyurothrips* ; *Zeugmatothripoides* is a new genus related to the recently described neotropical Hystrichothripid genus *Zeugmatothrips ;* and *Hoplandrothrips coffeae* is a new coffee thrips causing curled-leaf galls.

I am further able to show that *Dolichothrips varipes* is in no sense related to *Neoheegeria indica*, though treated by Karny as a synonym of that species, and to characterise more clearly *Gigantothrips gracilis* and *elegans*.

I am indebted to Dr. G. A. K. Marshall, F.R.S., of the Imperial Bureau of Entomology, and to the Authorities of the British Museum of Natural History for the bulk of this material, types of which are deposited in the British Museum collections.

## Genus **Sericothripoides,** nov.

Like *Sericothrips* ; pronotum without the well-defined antero-dorsal area of that genus and with a strong postero-marginal spine near each hind angle. Wings with setae on fore-vein only, lacking the one or two setae on lower vein at apex found in winged *Sericothrips*. Legs normally long.

Genotype, *Dendrothrips bispinosus*, Bagnall.

## Genus **Brachyurothrips,** Bagnall.

Near *Selenothrips*, Karny ; head without the reticulated sculpture between the eyes and less strongly lined in the post-ocular area ; maxillary palpi 2-segmented, as in *Selenothrips* ; antennae very long, at least three times as long as the head, joint 3 (with a long stem) longer than 4, and 8 bristle-like and three times as long as 7. Pronotum very strongly transverse ; dorsal surface plain, with setae disposed as in *Selenothrips*. Fore-wing much as in *Selenothrips*, but with the exception of a single basal seta, only the upper vein indicated by setae. Abdomen with segments 8 and 9 longer than in *Selenothrips*, 9 as long as broad distally and twice as long as 10 ; surface reticulation of the tergites almost obsolete ; ' comb ' of tergite 8 long.

This genus was originally imperfectly described from a mutilated example, and a second imperfect species (*indicus*, Bagn.) was referred to it, but now proves to be a true *Selenothrips*, as recorded below. It is impossible to refer the insect described below to the genotype, *B. anomalus*, Bagn., with any degree of certainty, and it is to be hoped that further material of the Seychelles species may shortly be discovered.

The genus is distinguished by the obsolete surface sculpture or reticulation of the head, pronotum and abdomen ; the long antennae, with a considerably elongated third joint ; the presence of the upper vein setae only in the fore-wing ; and the elongate ninth abdominal segment.

**Brachyurothrips hargreavesi,** sp. n.

♀ Length about 1·4 mm.

Colour yellow-brown; cheeks, pronotum and pteronotum anteriorly and at sides dark brown. Abdomen shading from yellow-brown basally to a rich reddish-brown, deepening in intensity posteriorly; the sides of 8 distally very dark and 9 largely almost black; 10 yellowish brown; arcuate fore-margins of intermediate segments 3–7 noticeably dark. Antennae with joints 1 and 2 yellowish brown, 3 in the distal third or thereabouts and 4 in distal half pale yellowish brown, 5–8 similarly pale yellowish to greyish brown, but with 5 lighter basally. Forelegs yellowish, femora in the basal two-thirds or thereabouts brown, and tibiae (especially at the upper and lower margins near base) yellowish brown; intermediate legs similarly but more deeply shaded; and hind legs with the femora and the basal half of tibiae uniformly dark brown. Fore-wings of a uniform light brown, hind-wings not quite so dark but with a dark median streak.

Head 1·6 times as broad across eyes (where it is broadest) as long; eyes large, prominent; cheeks rounded, converging to base, where the head is 0·8 as broad as across eyes; space between eyes somewhat considerable and the ocelli closer to each other than to the inner margins of eyes; anterior ocellus at apex of a slight hump;

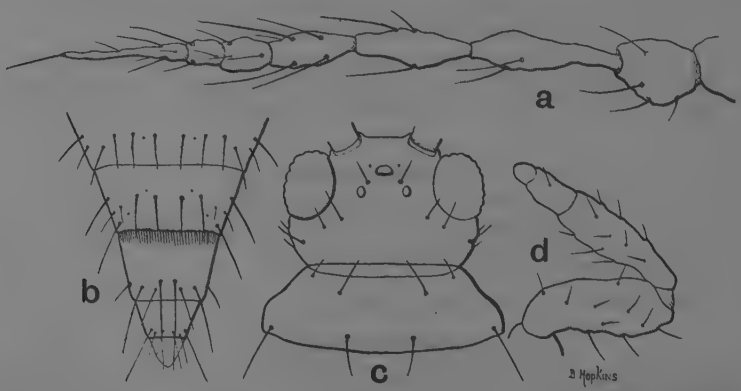



Fig. 1. *Brachyurothrips hargreavesi*, sp. n., ♀: *a*, antenna; *b*, terminal abdominal segments; *c*, head and thorax; *d*, foreleg.

setae short and slender, including a pair of interocellars; faint arcuate transverse striation in the postocular region, which is strongest medianly behind the ocelli and laterally. Antennae at least three times as long as the head; joint 3 with a short constriction at base, as in *S. rubrocinctus*, a long slender stem and broadest in its distal third; joint 4 with stem and stem-like distal production, broadest before its middle, with the inner margin more broadly arcuate than the outer; distal joints much as in *Selenothrips rubrocinctus*, but more slender and elongated, with 8 bristle-like and bearing a swelling near base. Relative lengths (and greatest breadths) of antennal joints 2–8 approximately as follows: 54(46), 95(28), 84(27), 68(30), 24(27), 22(16), 84(9) $\mu$. Pronotum very short and strongly transverse (98:286$\mu$), not much more than 0·6 the length of the head and about 1·15 times as broad; surface with a transverse series of 4 bristles remote from the posterior margin, and a similarly remote antero-marginal series; pterothorax massive, 1·6 times as broad as the head. Wings as figured for *B. anomalus*; fore-wing with a basal anterior series

of 3 long, fine bristles and a series of 4–5 on the distal half, and a single basal bristle on a plane corresponding with the lower vein ; bristles of costa long, up to three times as long as the median width of wing ; upper cilia shorter, widely spaced ; cilia of lower margin of both wings finely waved, long, close and fine ; microsetae of wing surface comparatively coarse. Legs normal. Abdomen as described for the genus, bristles on segments 8 and 9 longer than the segments bearing them.

Sierra Leone : Njala, 8.viii.1926, several ♀♀ on *Acalypha* (*E. Hargreaves*).

**Selenothrips indicus,** Bagn.

*Brachyurothrips indicus,* Bagnall.

This is a true *Selenothrips,* differing from the well-known and widely spread *S. rubrocinctus* in the much shorter and weaker bristles of the fore-wings and of the 9th abdominal segment.

Suborder TUBULIFERA.

Family Idolothripidae.

**Gigantothrips elegans** and **gracilis.**

In his memoir on " Thysanoptera from Siam and Indo-China " (Journ. Siam Soc., xvi, pt. 22, p. 152), Karny has treated my *Panurothrips gracilis* as a synonym of *Gigantothrips elegans,* whereas the material in my possession demonstrates that the Siam form is not the true *elegans* described by Zimmermann from Java.

As I have stated before, the Siam species (*gracilis*) is somewhat larger than the Java species (*elegans*) and has a distinctly larger tube, so much so that it is quite easy to separate mounted examples with the aid of a low power pocket lens. In addition the Siam species has the third antennal joint very distinctly longer as compared with the fourth. In a series of recent examples from Siam, all females, the measurements are as follows :—

Head, 45–47 ; tube, 90–93 ; antennal joints 3 and 4 c. 28 and 19 $\mu$ respectively.

On the other hand, measurements of Java examples are :—

Head ♀ 41–42 (♂ 40) ; tube ♀ 65–68 (♂ 51–55) ; and antennal joints 3 and 4 ♀ 21 and 16 (♂ 19 and 13·5) $\mu$ respectively.

Comparing the females it will be seen from these figures that the tube and third antennal joint are relatively one-third longer in *gracilis* than in *elegans* ; further that the tube is approximately twice as long as the head in *gracilis,* but only 1·6 times as long as the head in *elegans,* and the third antennal joint is 0·6 the length of the head in *gracilis* and only 0·5 the length of the head in *elegans,* apart from being longer in comparison with the fourth joint.

The synonymy should be as follows :—

*Gigantothrips gracilis* (Bagnall).

*Panurothrips gracilis,* Bagnall 1909, Trans. Nat. Hist. Soc. N'd. & D'ham, n.s. iii, pt. 1, p. 208 (p. 28 sep.), Pl. vii, figs. 7–8.

Bangkok, Siam, ♀♀ on " bo tree " (*H. Hillman*).

*Gigantothrips elegans,* Zimmermann 1900, Bull. Inst. Bot. Buitenzorg, vii, p. 18.

*Panurothrips gracilis* Bagnall (in part) 1910, *op. cit.,* pt. 2, p. 524 (p. 3 sep.), Pl. xiv, figs. 1–3.

Java and perhaps the Philippines.

Family Hystrichothripidae.

Genus **Zeugmatothripoides,** nov.

Near *Zeugmatothrips,* Priesner. Head with *two prominent spine-set tubercles ornamenting the cheeks near middle ;* postoculars as in *Zeugmatothrips ;* mouth cone

shorter than the prosternum, blunt and rounded. Antennal joints 1 *and* 2 *only armed with long prominent knobbed bristles* (1, 3, 4 and 5 in *Zeugmatothrips*) ; 3 *longest of all ;* sense cones long, slender and forwardly directed, *joints* 3–5 *furnished with two and* 6 *with one dark* (and therefore conspicuous) tapering setae in addition to more slender pale ones. Pronotum short, as in *Zeugmatothrips ;* legs also as in *Zeugmatothrips ;* wings present, slender. Abdomen broad and sides rounded in the first five segments, then tapering to tube ; lateral bristles posteriorly directed, stout, blunt and set on prominent tubercles with a shorter accessory bristle near base of each tubercle ; those on 4–7 longest. Tube long, more than twice as long as the head, badly formed, with weak terminal hairs, surface thickly clothed with long hairs, which are much longer than the breadth of the tube.

Genotype, *Zeugmatothripoides africanus*, sp. n.

The type would appear to be an ill-formed, nymph-like exaggeration of *Zeugmatothrips*, chiefly differing in the form and chaetotaxy of the head and antennae.

**Zeugmatothripoides africanus,** sp. n.

♀ Length about 3·2 mm., breadth of pterothorax 0·63 mm. Colour yellowish, irregularly shaded with brown with considerable mottlings of red to crimson hypodermal pigmentation ; tube reddish brown ; sides of head, pterothorax and apical abdominal segments, dark brown to blackish brown ; fore-femora and fore-tibiae in the basal half, brown to dark brown ; intermediate femora (except extreme base) and tibia (except distally) similarly dark brown ; hind femora yellow with brown mottlings distally, and hind tibia, except for knee and distal third, brown. Bristles, pale. Antenna, except for joints 1 and 2 which are yellowish brown, of a pale yellowish tinge, apex lightly shaded with grey.

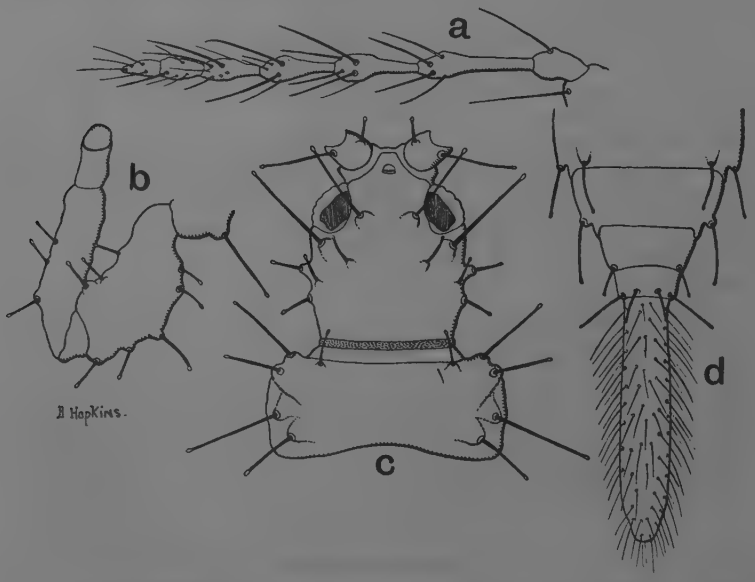



Fig. 2. *Zeugmatothripoides africanus*, sp. n., ♀: *a*, antenna ; *b*, foreleg ; *c*, head and thorax ; *d*, terminal abdominal segments.

Length of head to line above eyes (and breadth across eyes) where it is broadest, 338(269); length (and greatest breadth) of pronotum, excluding the prominent trochanters, 188(376); breadth of abdominal segment 3 where abdomen is widest, 800; length (and basal and apical breadth of tube) 800(150:52) $\mu$. Length (and greatest, breadth, excluding tubercles) of femora and tibia: i, 275(110), 262(78), and iii, 400(94), 400(75) $\mu$. Length of longest cilia on tube, 275; of knobbed postero-angular bristles on abdominal segments 4–7, 150–162; on 8 and 9, 94 and 138 respectively; on antennal joints 1 and 2, 125–145; postoculars 175, pronotal antero-angular 150–162, sub-antero-lateral 94 and postero-angular 112.

SIERRA LEONE: Njala, on kola, 17.viii.1928 (*E. Hargreaves*).

**Dolichothrips varipes,** Bagn.

Notwithstanding Karny's comments (Mem. Dept. Agric. India, ix, no. 6, 1926, p. 215) this is not only a good species, but also a true *Dolichothrips* and therefore not comparable with *Neoheegeria indica,* Hood, much less identical therewith.

The following are the length (and breadth) of the head, 256(152), of the fore-tibia, 202(38), and of the tube (the breadth being basal) 162(80) $\mu$; and the relative length (and breadth) of the antennal joints 3 to 8 is approximately as follows: 76(27), 73–76(28), 65(24), 58(23), 47(22), 27 $\mu$.

I have examples of *Neoheegeria indica,* but the following measurements for the purpose of comparison are from Hood's original description: length and (breadth) of head, 191(156), and length (and basal breadth) of tube, 120(68) $\mu$; relative length (and breadth) of antennal joints 3–8: 46(28), 44(28), 42(26), 40(23), 38(19), 22(11) $\mu$. The fore tibia is of the usual short form, the length (and breadth) in my collection being 94(36) $\mu$.

Originally described from India, I have recently received examples of *Dolichothrips varipes* from the British Sudan, Khartoum, on cotton, 29.iv.1926 (*H. W. Bedford*).

**Dolichothrips karnyi,** Faure.

*Dolichothrips karnyi,* Faure 1925, S.A. Jl. Nat. Hist., v, p. 153, Pl. xv, figs. 16–18.

This is a good species, and in describing it Faure has noticed its close kinship with *D. jeanneli,* Bagnall, the long pronotum and relatively shorter prothoracic setae, and the short abdominal bristles at hind angles of segment 9 (being 0·8 the length of the tube in *jeanneli,* as compared with 1·2 the length of tube in *karnyi*), being the chief distinguishing features of *jeanneli* as compared with *karnyi,* to which may be added the longer antennal joints 3 and 4 as compared with 4 and 5 in *jeanneli.*

I have now received examples of *karnyi* and append the following relative measurements of antennal joints 3–8:—

*D. jeanneli.*—♀ 157(32), 127(34), 111(33), 82(32), 67(29), 37(17) $\mu$.

*D. karnyi* from Tanganyika.—1♀ 121(28), 114(32), 108(29), 80(28), 71(27), 33(16) $\mu$.

*D. karnyi* from S. Africa (Faure).—♀ 124(26), 113(29), 106(26), 84(26), 70(26), 29(15) $\mu$. ♂ 100(26), 96(30), 93(30), 81(30), 67(26), 30(15) $\mu$.

TANGANYIKA TERR.: Arusha, Rasha-rasha, viii.1926, ♀♀ on onion (*A. H. Ritchie*).

**Haplothrips ceylonicus,** Schmutz.

The antenna of this species is figured by Karny (Bull. Deli Proefst. Medan, 1925, p. 45, fig. 17). The species differs from *ganglbaueri* and *sororculus* of Schmutz in

having 9–11 duplicated cilia of the fore-wing, as compared with 3–6, and in the unarmed fore-tarsus in the ♀. The sub-basal bristles of the fore-wings are disposed as in *subtilissimus* (Hal.), but the second one is distinctly shorter than in that species. The insect comes nearest to *subtilissimus* and like that species is found on leaves. The examples noted here have the fore tibiae yellow, brownish basally, and the intermediate antennal joints lemon-yellow; the tube is somewhat shorter than in *subtilissimus*, and the terminal hairs are 1·33 times as long as the tube, instead of about the same length, as in *subtilissimus*.

Federated Malay States: Sepang, on coconut, 10.viii.1928 (*G. H. Corbett*).

**Hoplandrothrips hystrix,** sp. n.

♂. Length about 2·8 mm., breadth of pterothorax 0·54 mm.

Colour yellowish brown to brown, head between eyes and basally thorax and abdomen with considerable crimson hypodermal pigmentation; fore-tibiae and all tarsi yellowish; bristles yellowish; wings lightly fumate, hind wing with a

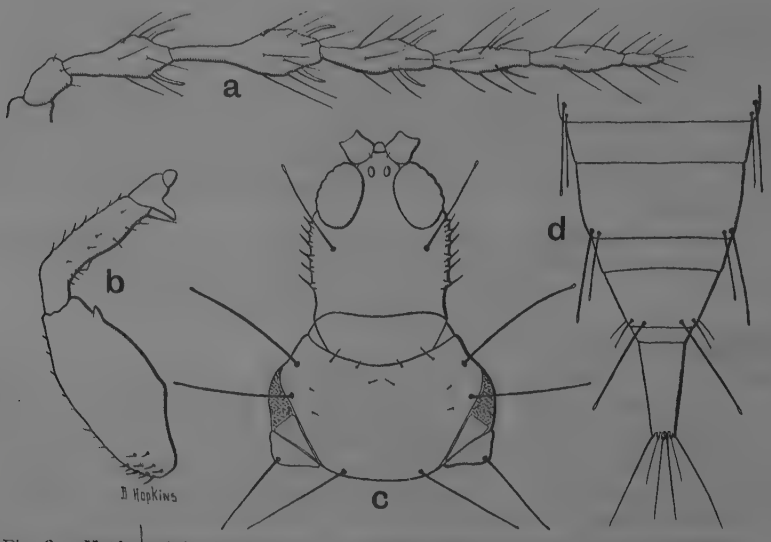



Fig. 3. *Hoplandrothrips hystrix*, sp. n., ♂: *a*, antenna; *b*, foreleg; *c*, head and thorax; *d*, terminal abdominal segments.

longitudinal brown line. Antennal joints 1 and 2 concolorous with head, 2 inclined to be paler distally, 3 yellow, 4 and 5 similarly yellow, but lightly shaded with brown in or about the distal half, the extreme apex being yellowish, 6 pale yellowish brown (paler distally and basally), 7 and 8 pale yellowish to greyish brown with 7 pale basally.

Head not quite 1·5 times as long as broad across eyes and 1·5 times as long as the pronotum; cheeks converging somewhat sharply near eyes and more gradually and strongly basally, armed with several spines set in strong tubercles, the spines decreasing in length towards the eyes and measuring 40 to 19 $\mu$ in length. Eyes finely facetted, occupying less than 0·4 the dorsal length of the head; postocular bristles placed well back, long (175 $\mu$), nearly 1·6 times as long as an eye. Antennae

with joints 3 and 4 strongly claviform and broader than any of the following joints, which are unusually slender; 5 semi-claviform, with longish produced distal part making it almost spindle-shaped; 6 and 7 elongate, the apical joint 8 being about 0·6 the length of 7. Pronotum sharply widening from anterior angles, widest in the basal half, where it is 1·9 times as broad as long. Antero-angular bristles set exceptionally far back, with mid-lateral and postero-marginal all very long and slender, ranging from 240–300 $\mu$ in length; postero-angulars shorter, set on tubercles, stouter, darker, with ends slightly knobbed, only about 130 $\mu$ in length; antero-marginals vestigial. Fore-coxae prominent, slightly produced and set with several spines in addition to the usual seta, which is knobbed and about 88 $\mu$ in length; fore-femur with a pair of teeth near apex within; fore-tibia with inner apical angle acute and furnished with a tooth near basal third within; fore-tarsal tooth large. Pterothorax approximately as wide as breadth across fore-coxae, but narrowing to juncture with abdomen. Wings strongly and closely ciliate; fore-wings about 95 $\mu$ wide across middle, with 18–21 duplicated cilia; sub-basal bristles equidistant and on a straight line, 1 and 2 subequal, knobbed and prominent, 100–110 $\mu$, third fine and pointed, c. 50 in one example and 88 $\mu$ in the other. Abdomen elongate, gradually decreasing in width to segment 9; segments transverse; tube about 0·65 the length of head, gradually narrowed from base (where it is about 0·5 as broad as long) to apex; basal excavation broad and deep. Length of spines on segment 9 about 65 $\mu$; of outer and inner bristles on segment 8, 162 and 128 respectively, and on 9 about 200 $\mu$, faintly knobbed; of apical hairs 230 $\mu$.

Length of head to anterior margins of eyes (and breadth across eyes), 338(230); length of pronotum (and breadth across fore-angles and at base), 226(250 and 432); breadth across fore-coxae, 540 $\mu$; length (and breadth at base and at tip) of tube, 222(108 and 47) $\mu$; length (and breadth) of fore-femur, 440(175), and of fore-tibia, 284(68) $\mu$; breadth across segment 2 of abdomen, c. 486 $\mu$. Relative lengths (and breadths) of antennal joints 3–8 approximately: 122(50), 132(49), 113(32·5), 84(24), 68(24), 41(15) $\mu$.

SIERRA LEONE: Njala, 3 ♂♂, on grapefruit bark, 10.iv.1927 (*E. Hargreaves*).

A large and very distinctive species with long pale antennae.

**Hoplandrothrips coffeae,** sp. n.

♀. Length about 1·5 mm., breadth of pterothorax c. 0·34 mm.

Colour brown to chestnut-brown; in lighter specimens head, pronotum, anterior margins and sides of pterothorax, and basal half of tube darker; fore-tibiae yellowish brown and all tarsi yellowish; basal antennal joints concolorous with head, 2 inclined to be lighter distally, 3 pale yellow with apical half or thereabouts shaded with pale yellowish brown, 4 light brown, pale basally and distally, 5 similarly light brown and pale, 6–8 uniformly grey-brown, except for extreme base of 6 which is paler. Wings lightly fumate; hind wings with a brown sub-basal costal line and a similar but longer median line.

Head shorter, quadrate, about as broad as long, cheeks slightly narrowing in their basal third and smooth but for one prominent short sharp spine at about the basal third, as in *bispinosus*, Pr., and *bispinoides*, Bagn. Eyes occupying about 0·45 the dorsal length of head, postoculars set only slightly back, colourless, blunt, longer than the length of an eye, being from 84–94 $\mu$ in length; ocelli well forward, large, the outer margins of the posterior pair closely approaching the inner margins of eyes, anterior ocellus forwardly directed. Antennae stout, with joint 3 especially very broad compared with its length, being scarcely more than 1·4 times as long as broad. Pronotum short and strongly transverse, little more than 0·6 as long as the head and 2·25 times as broad as long; antero-angular, mid-lateral, postero-angular and postero-marginal setae well developed, blunt, ranging from 54 to c. 70 $\mu$ in length. Fore-tarsus with

a somewhat stout tooth. Wings somewhat closely ciliate; fore-wing about 72 $\mu$ broad near middle, with 6 duplicated cilia; sub-basal setae in a straight line, 1 and 2 a little more closely set than 2 and 3; 1 and 2 stiff, erect, blunt, 54 and 60 $\mu$ long; 3 fine, curved and pointed, about 28 $\mu$ long. Abdomen linear, about as broad as the pterothorax, with the segments strongly transverse. Tube about 0·75 as long as the head, terminal hairs (140 $\mu$) 0·9 as long as the tube. Abdominal bristles moderately long, those on 9 about 135 and the outer (and longer) on 8 about 118 $\mu$ in length.

♂. More slender; fore-femora with a pair of teeth near apex within, and fore-tibia with a single tooth near basal third within; fore-tarsal tooth stouter. Excavation at base of tube broad and deep. Spines of 9th abdominal tergum about 54 $\mu$ long.

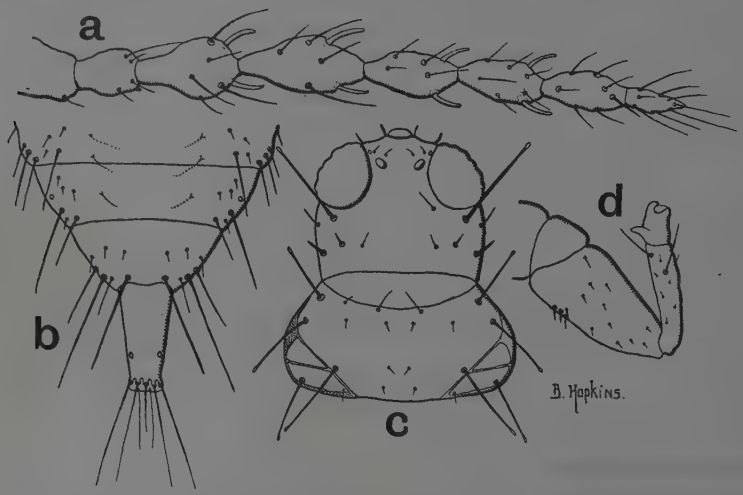



Fig. 4. *Hoplandrothrips coffeae*, sp. n., ♀: *a*, antenna; *b*, terminal abdominal segments; *c*, head and thorax; *d*, foreleg.

Length of head to anterior margins of eyes (and breadth across cheeks), 202(202); length (and breadth) of pronotum, 128(290); and length (and breadth at base and at tip) of tube, 155(74 and 36·5) $\mu$. Relative lengths (and breadths) of antennal joints 3–8 approximately: 65(46), 73(43), 61(34), 57(30), 52(27), 32·5(14) $\mu$.

Tanganyika Terr.: Bukoba, Kamachumu and Rubunge, ix.1926, curling leaves of coffee (*A. H. Ritchie*).

# THE ECONOMIC STATUS OF INDIAN THYSANOPTERA.

By T. V. Ramakrishna Ayyar, B.A., Ph.D., F.Z.S.,
*Madras Agricultural Department.*

In India the economic rôle played by insects of the order Thysanoptera, popularly known as " thrips," has not become so conspicuous as in some other parts of the world. The different kinds of thrips affecting specific crops such as wheat, oats, tobacco, fruits, onions, cacao and hot-house plants, in Europe, America, the West Indies and many tropical areas, are insects of established notoriety, and some of them cause severe and extensive damage to valuable crops from time to time ; but so far no species of Thysanoptera has as yet gained such prominence in India. Neither Lefroy in his book on " Indian Insect Pests " (1904), nor Fletcher in his publication on " South Indian Insects " (1914), has recorded any insect of this group as a definite pest among the numerous forms listed as injurious. In his other and more voluminous text-book, " Indian Insect Life " (1909), however, Lefroy, in the course of a brief chapter devoted to Thysanoptera, just refers to the three Indian species which were the only ones recorded till then, *viz.* : *Idolothrips halidayi* and *Phloeothrips anacardii*, described by Newman in 1856, and *Panchaetothrips indicus*, described by Bagnall in 1912 ; and only one of these, the last, had any economic importance, having been noted on turmeric in Madras.

During the course of his studies on the systematics and bionomics of Indian Thysanoptera for the past few years, the writer has noted a few forms that have begun to attract the serious attention of the farmer and the economic entomologist and which are likely to attain the status of pests. The inclusion of species of Thysanoptera among injurious insects has been often looked upon with some scepticism by entomologists in the past ; but evidence is frequently forthcoming to show that some of these insects are undoubtedly harmful. With the idea of investigating this question the author has gathered some data, which are here briefly recorded. In addition to notes on the host relations and food habits of those forms which have already justified their claim to be regarded as pests, a list is added of such of the others as may possibly assume the status of pests under favourable conditions in the future. The main object of this paper, therefore, is to invite the attention of farmers and economic entomologists to the present activities and the possible potentialities of this little-known group of insects in India.

Before dealing with the different species, it may not be out of place to add a few remarks on the food habits of Thysanoptera in general. The great majority of them are plant-feeders, and these are found chiefly on the softer tissues of various plants, such as flowers, shoots, buds, tender leaf-sheaths and leaves, and often under bark ; in almost every flower one usually comes across some thrips or other. The method of feeding consists in lacerating the soft and sappy portions of vegetable tissue and sucking up the juice. This drainage of the sap causes different kinds of injury ; in some plants the leaves curl or roll up, in others the flowers fade and drop prematurely, and in some others the shoots and buds wrinkle and fade. There are also some thrips which produce galls. Though some species are found feeding on various plants, many forms confine themselves exclusively to one kind of food-plant. Most Thysanoptera are phytophagous, but a few have been noted to be carnivorous—feeding on the eggs of minute creatures, such as small insects and mites.

The most important species from an economic point of view are the following :—

*Thrips oryzae*, Williams. The rice thrips is a small black species found on paddy seedlings in almost all the important rice tracts of South India. It occurs in Tanjore, Malabar, Chingleput, Mysore, etc. It is also recorded on rice in Assam and Java.

When the rains are delayed the young seedlings suffer considerably; the tender shoots and leaves become curled, turn pale and dry up, unless control measures are undertaken.

*Heliothrips indicus*, Bagnall. This insect has been noted on a variety of crops such as ragi (*Eleusine*), daincha (*Sesbania*), groundnuts, onions, *Colocasia*, etc.; in Bombay it has been found doing damage to potatoes and cabbage; in North India to indigo, onions and brinjal (egg-plant). It often does appreciable damage to groundnuts, causing the disease known as " tamara novu " in Tamil. The species has been recorded as a serious cotton pest in Egypt.

*Scirtothrips dorsalis*, Hood. This insect has been found doing appreciable damage to chillies in the Guntur tract for the past two or three seasons. It has since been noted in other parts of South India on castor, brinjal and a few other plants. When the writer first collected this species in 1916 nothing was known of its injurious habits.

*Taeniothrips distalis*, Ky., and *T. longistylus*, Ky. These two species are very common in South India and have been noted on a variety of food-plants. On lab-lab and groundnuts they have occasionally been found causing severe damage by infesting the flowers in numbers and causing them to fade and drop.

*Taeniothrips lefroyi*, Bagn., and *T. setiventris*, Bagn., have been observed on tea in Darjiling.

*Thrips tabaci*, Lind. This is a very well known insect and distributed all over the world, being a notorious pest of onions and tobacco; latterly it has been found on cotton also in some countries. In India it has been noted on cotton and cabbage, but not as a pest.

*Rhipiphorothrips cruentatus*, Hood. The grape-vine thrips has been observed in Coimbatore, Bangalore, Bezwada, Madura and the Punjab. On young grape leaves it causes noticeable injury. It is also found on *Eugenia*, *Terminalia*, rose, etc., but it is only grape-vine that suffers appreciably.

*Heliothrips haemorroidalis*, Bouché. The hot-house thrips of Europe and America is found all over the world as a pest of plants grown in glass-houses. In India it has been found in Bangalore and Coimbatore doing serious damage to the foliage of garden crotons.

*Selenothrips rubrocinctus*, Giard. The cacao thrips is well known in the West Indies and other cacao-growing countries such as the Gold Coast and Ceylon. In South India it has been recently noted on cashew nut trees in Cochin and Malabar, though not as a pest.

*Haplothrips tenuipennis*, Bagn. This is the only insect of the subdivision Tubulifera that has been noted as a pest of an important crop, all the species mentioned above being members of the suborder Terebrantia. It has been recorded as causing injury to tea in Assam during the past few years.

*Arrhenothrips ramakrishnae*, Hood, and *Rhynchothrips vichitravarna*, Ramakrishna, are also tubuliferous species causing very serious leaf-curling of the garden plant, *Mimusops elengi*, in the town of Coimbatore and its vicinity.

The species dealt with above include some that are well known pests and some others that are tending in that direction. It would, therefore, be well for economic entomologists to turn their attention to these insects and endeavour to devise measures to check their multiplication and distribution. The author also considers it advisable to put on record whatever information we have regarding localities and food-plants of all the other species of the group which have been noted on cultivated crops in India and which, though not doing any real harm at present, may have chances of becoming injurious at any time when the conditions prove favourable.

TEREBRANTIA.

*Hydatothrips ramaswamiahi*, Ky. Noted on indigo and swordbeans in Coimbatore. It has recently been collected in numbers in grass sweepings in Coimbatore.

*Dendothrips indicus*, Bagn. On arrowroot, North Malabar.

*Dendrothrips bispinosus*, Bagn. On tea leaves, Kotagiri, Nilgiris, 4,000 ft.

*Ayyaria chaetophora*, Ky. In flowers of cow-pea (*Vigna catjang*), North Malabar.

*Frankliniella sulphurea*, Schm. A very common insect, found on numerous plants all over South India ; among these are *Dolichos lablab*, *Hibiscus* spp., lucerne, chrysanthemum, chillies, jasmine, and groundnuts.

*Taeniothrips jonnaphila*, Ramakrishna. On maize and sorghum in Coimbatore, Guntur and Samalkota.

*Isoneurothrips orientalis*, Bagn. In numbers inside jasmine flowers, Coimbatore, Kollegal, Pusa ; in flowers of *Morinda tinctoria*, Coimbatore.

*Thrips florum*, Schmutz. A very common form found in flowers of many plants, sometimes in numbers. The food-plants include sunn hemp (*Crotalaria juncea*), indigo, pomegranate, cumbu (*Pennisetum typhoideum*), jasmine, banana, lab-lab, *Eugenia* and orange ; found all over South India.

*Thrips nilgiriensis*, Ramakrishna. Inside orange blossoms, Runnymede, Nilgiris, 4,000 ft.

*Thrips palmi*, Ky. In lab-lab flowers, Coimbatore ; in lantana flowers, Nilgiris.

*Thrips pandu*, Ramakrishna. In flowers of citrus plants, Coimbatore.

*Stylothrips brevipalpis*, Ky. In chrysanthemum flowers, Coimbatore and Nilgiris.

*Bregmatothrips binervis*, Kobus. In leaf tips of sugar-cane, South Arcot and Coimbatore.

*Anaphothrips oligochaetus*, Ky. In flowers of cotton, pomegranate and *Caesalpinia*, Coimbatore.

*Anaphothrips ramakrishnae*, Ky. In numbers in leaf-sheaths and flower-heads of cumbu, Coimbatore.

*Anaphothrips citricinctus*, Bagn. In arrowroot shoots, North Malabar ; in cholam (*Sorghum*) leaf-sheaths and on grasses, Coimbatore.

*Panchaetothrips indicus*, Bagn. This insect has been noted on turmeric in Madras, Coimbatore, Malabar and Travancore. On the West Coast it has been found on arrowroot leaves also. Recorded from Pusa on banana and turmeric. It sometimes occurs in numbers, but whether it does any real damage is not yet certain.

*Tryphactothrips rutherfordi*, Bagn. Found on tender shoots of brinjal, cotton and *Datura* in Coimbatore.

TUBULIFERA.

*Eurhynchothrips ordinarius*, Hood. Has been noted in flowers of agathi (*Sesbania*) in Coimbatore.

*Haplothrips ceylonicus*, Schm. This is a very common insect and may be found in some numbers in many flowers, such as those of mango, jasmine, lantana, and coconut, in different parts of South India. The author suspects that it may cause some injury to mango flowers, in which it is found very commonly.

*Haplothrips ramakrishnai*, Ky. In chrysanthemum flowers, Coimbatore.

*Haplothrips soror*, Schm. In chrysanthemum and lantana flowers, Coimbatore and Nilgiris.

*Gynaikothrips pallipes*, Ky., and *G. chavicae*, Zim. Found in leaf galls on pepper (*Piper nigrum*), Wynaad, Malabar, 2,000 ft.

*Kleothrips subramanii*, Ramakrishna. On leaves of coconut palm, Chingleput, near Madras.

# NEW INJURIOUS HISPINAE.

By S. Maulik.

At the request of the Imperial Bureau of Entomology I have had pleasure in studying the forms described below. In the alcoholic material examined some adult forms were accompanied by larvae ; I am thus afforded another opportunity of publishing further notes on the anatomy of Chrysomelid larvae. The drawings are by Mr. A. J. E. Terzi.

**Promecotheca nuciferae,** sp. nov. (fig. 1).

Body oblong, parallel-sided, with the apex rounded. General colour light buff ; eight apical segments of antennae black, third segment smoky ; eyes black ; mandibles black ; all tarsi, a dorsal area on the hind femora, and tibiae near the points of articulation, piceous ; abdominal sternites very largely mixed with piceous.

*Head* with the eyes as broad as the prothorax ; somewhat constricted behind the eyes ; interocular area convex, with a median longitudinal impressed line and with its surface extremely minutely punctate, the punctures being detected only under a high power. Antennae covered with stiff hairs ; the first segment thick and convex on the inner side ; second small, rounded, constricted at base ; third, fourth and fifth long, about equal to each other ; sixth much shorter than fifth and about equal to or very slightly longer than seventh ; from the eighth segment the

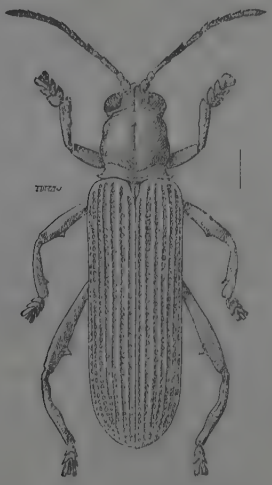


Fig. 1. *Promecotheca nuciferae*, sp. n.

antennae become gradually somewhat thinner ; eighth, ninth and tenth about equal in length ; eleventh somewhat longer and bluntly pointed. *Prothorax* oblong, longer than broad, front margin widely arched, basal margin somewhat sinuate ; in front of the base the usual constriction present in all species of the genus has the particular shape which is shown in the figure ; sides rounded ; upper surface uneven, with a slight depression on each side and a longitudinal median line ; seen under a high power the background is very finely shagreened, in some parts finely reticulated,

and then sparsely and finely punctate. Each corner has a tubercle bearing a fine seta. *Scutellum* depressed, with the apex rounded and the sides parallel. *Elytra* slightly broader at the shoulders than the prothorax, punctate-striate, each elytron having eight longitudinal series of punctures, which are deep and closely placed; no scutellar row of punctures; intervals between the rows costate, the second and sixth from the suture appearing to be somewhat stronger. Under a high power the apex of the elytra is seen to bear very fine hairs. *Underside* smooth, with the abdominal sternites very sparsely covered with fine hairs; middle and hind femora with a spine on the inner side, middle tibiae with similar spines on the inner side, hind tibiae without such spines; front tarsi enlarged, which is often a secondary sexual character of the male.

*Length*, 8 mm.; breadth, 2·5 mm.; antenna, about 4 mm.; posterior femur, 3 mm.; posterior tibia, 1·75 mm.

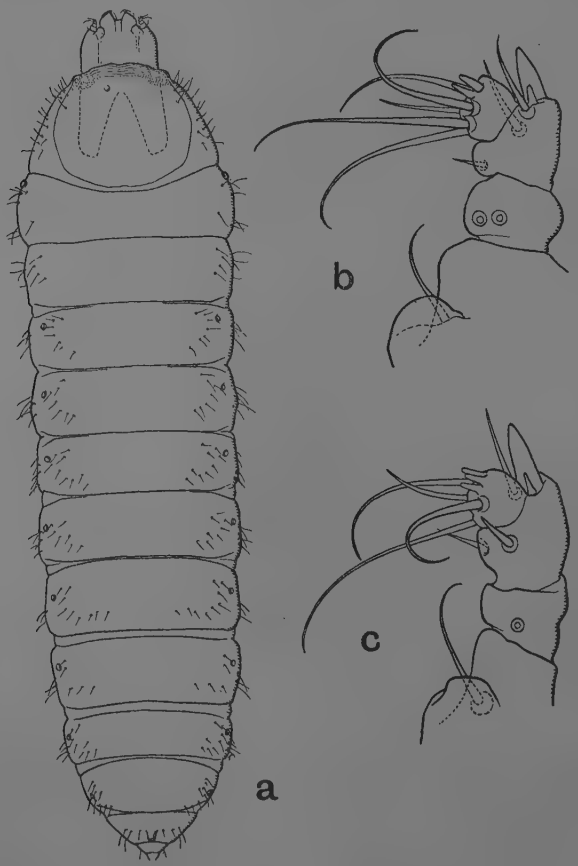



Fig. 2. *Promecotheca nuciferae*, sp. n.: *a*, larva, dorsal view; *b*, antenna of larva. *P. cumingi*, Baly: *c*, antenna of larva.

CELEBES: Gorontalo, mining in older leaves of coconut palm, iii.1928 (*Dr. A. Reyne*).

*Type* in the British Museum.

Described from one example.

This species resembles *P. cumingi*, Baly, but differs in having the prothorax broader in relation to the head and the base of the elytra, and in having the general colour somewhat lighter.

LARVA (fig. 2, *a*).

The larva is about 10 mm. in length (cleared and mounted in balsam) and is composed of fourteen segments including the head, three thoracic and nine abdominal segments, the anal sucker forming a fourteenth segment. The body is almost parallel-sided, the prothorax narrowing abruptly in front and the last two abdominal segments also narrowing posteriorly. Each abdominal segment is somewhat rounded at either side, but without any projection or spine; the prothoracic segment is not laterally rounded. There are nine pairs of spiracles, one on the mesothorax opening anteriorly and laterally and one on each of the first eight abdominal segments opening dorsally, being situated, as usual, on the lateral area. The head is typical of a leaf-miner, being a large, strongly chitinised and posteriorly deeply bilobed structure, most of which is embedded in the prothorax. The mouth-parts and antennae are situated at the anterior edge. The mouth-parts consist of a fringed labrum, two triangular mandibles with sharp cutting edges, and a bilobed and thickly fringed labium. The antennae (fig. 2, *b*) have a broad base bearing three segments; internal to the second is a lobe and seta; the third segment bears seven setae of various sizes. The prothorax is extensively chitinised (area shown in the figure by a fine line), more strongly so at the anterior end on both the dorsal and ventral sides, where the surface is strongly shagreened. Except this part the whole skin is smooth.

PUPA (fig. 3, *a*).

The pupa is 8 mm. long (specimen in alcohol, 9 mm. mounted in balsam). The head, thorax, wings and legs, are seen through an enveloping sheath. In the present preparation the insect was evidently killed at a stage when the adult structures were not well developed. But their position is shown in the drawing. The abdomen is composed of nine segments, the first seven bearing a pair of spiracles opening on the dorsal side. On the ventral surface of each of the abdominal segments are two transverse series of strong hairs or bristles, those in the anterior row being less numerous and further apart. Round the anal segment is a series of strong, short spinules. On the dorsal surface of each abdominal segment there are strong and short spinules arranged in pairs in a transverse line, usually in three pairs and accompanied by long setae. Next, also in a transverse row, are hairs more or less symmetrically arranged. On the fifth, sixth and seventh segments the spinules are stronger and on the fifth and sixth the median pair are joined by a transverse chitinised fold.

As compared with *Promecotheca cumingi*, there is a slight difference in the larval antennae (fig. 2, *b*, *c*), though the general structure is the same. The segments appear to be somewhat different in shape. The number and length of papillae also show slight differences. In the pupal skins (fig. 3, *a*, *b*) there is a difference in the shape of the abdominal segments; in *nuciferae* they are narrowed, while in *cumingi* they are broader. The median dorsal spinules on the fifth and sixth abdominal segments are not joined in *cumingi* by a transverse fold.

In drawing attention to these differences in the larvae and pupae of the two species it is not intended here to lay stress on their specific nature. But it is meant that such differences occur in the preparations examined.

**Promecotheca soror,** sp. nov.

Body elongate, narrow, parallel-sided. General colour red-brown ; head, thorax, underside and legs shining ; elytra subnitid ; in some cases the elytral colour has a reddish tint ; eight apical segments of antennae blackish ; legs very dark brown, hind ones often black ; underside dark brown, abdominal sternites often blackish. A small apical area of the elytra is black.

*Head* constricted behind the eyes, which are strongly convex ; interocular space with convex areas and a median longitudinal sulcus. The first segment of antennae

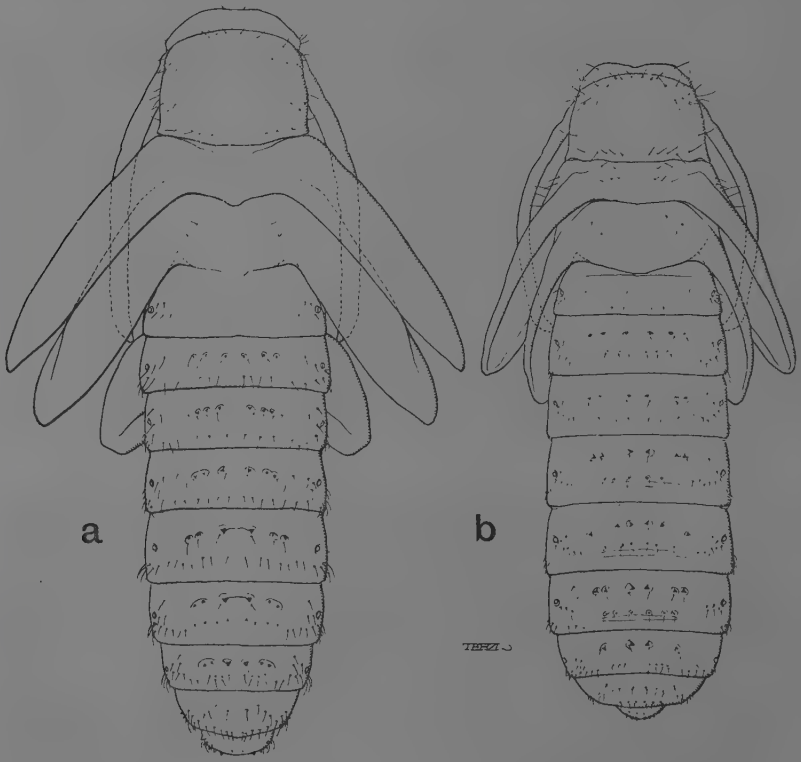



Fig. 3. Dorsal view of pupa of : *a*, *Promotheca nuciferae*, sp. n. ; *b*, *P. cumingi*, Baly.

thickened ; second very small ; third the longest ; fourth slightly longer than fifth ; fifth, sixth and seventh of successively diminishing length ; eighth distinctly shorter than seventh ; eighth, ninth and tenth about equal to each other ; eleventh longer, ovate and pointed. *Prothorax* longer than broad, with the sides rounded ; deeply constricted in front of the base ; each of the four lateral angles with a fine seta ; upper surface with a faint median longitudinal impression, closely covered with shallow punctures on a finely shagreened background. *Scutellum* narrow, almost parallel-sided, with the apex rounded, surface sometimes depressed, granulate. *Elytra* broader at base than the prothorax ; punctate-striate, without a scutellar

row of punctures ; each elytron having nine rows of punctures across the base and eight across the middle ; below the humerus two short rows which anastomose in a confused way between the fourth and fifth rows ; the interstices between the series of punctures seem to be raised, the punctures themselves being large and squarish. Seen in profile the apical area, particularly the margin, bears a few erect hairs. *Underside* smooth, shining, impunctate ; the last abdominal sternite thickly punctate and bearing long stiff hairs, and with a semicircular impression ; on the other abdominal sternites a few scattered hairs may occur. Each femur with a sharp tooth on the underside.

*Length*, 8·25 mm. ; length of antenna, 2·75 mm. ; hind femur, 2·75 mm.

Moluccas : Mongoli, ii.1928, damaging coconut palm (*A. Reyne*).

Described from seven examples.

*Type* in the British Museum.

This species closely resembles *Promecotheca cumingi*, Baly, but differs in having (1) the general build somewhat more robust ; (2) the prothorax somewhat broader ; (3) the interstices between the longitudinal series of the punctures on the elytra more pronounced, and (4) the apical area of the elytra black.

It is possible that what appear to be different species now may prove to be varieties of the same species when more material and experimental data accumulate.

The occurrence in the various island groups of the Pacific of species strongly resembling each other yet appreciably differing seems to me to lend support to the principle I have enunciated, that in island faunas species tend to become more plastic (British Museum publication on Insects of Samoa, Coleoptera, Chrysometidae, Feb. 1929, p. 191). I have noticed appreciable but apparently constant variation in strongly similar species of the genera *Promecotheca* and *Brontispa*, which are all pests of the coconut palm.

**Octotoma tessellata,** sp. nov. (fig. 4).

Body oblong, parallel-sided, with the lateral edges irregularly serrated ; apical margin of elytra at the external lateral angle expanded, with the edge more widely serrated, but not expanded at the sutural angle ; antennae short, with a terminal laterally flattened club beginning with the seventh segment ; elytra with deep punctures and with several much elevated, curved and irregular ridges. On the upper side the colour is not uniform, but chequered with brown and piceous without forming any definite pattern ; on the underside the thoracic sterna and the lines of junction between the abdominal sternites are black and the latter brown, the legs being chequered with brown and piceous.

*Head* narrower than the prothorax ; the interocular space with a deeply impressed longitudinal channel, which is somewhat broad at base and sharply narrows towards the apex ; between this channel and the eye the surface is rough, bearing a few white hairs. Eyes fairly convex and encircled along the rim by whitish hairs. Clypeus with a sharp median longitudinal ridge. Antennae shorter than the length of the head and pronotum together ; first segment somewhat larger than second ; third longer than second or fourth ; fifth longer than fourth or sixth ; seventh large, its articulation with the eighth irregular in outline ; eighth and ninth about equal, forming the middle part of the club ; tenth and eleventh forming the apex of the club. The last five segments forming the club show signs of being fused together. Segments 1–6 sparsely covered with whitish hairs, the club being more closely covered with silky pubescence. *Prothorax* somewhat longer than broad, with the sides parallel and their margins irregular ; basal margin undulated in accord with the shape of the front margin of the elytra ; anterior lateral angle with two small projections, the front one having a fine seta ; posterior lateral angle acute ;

upper surface with the background very finely shagreened, and with very rough sculpturing consisting of a median longitudinal ridge much elevated at the centre, many shallow circular depressions on the lateral area, a shallow basal depression and many smaller punctures. *Scutellum* broader than long, completely imbedded in the elytral projections at the base ; surface finely shagreened. *Elytra* broader at the base than the prothorax ; the surface shagreened. At the basal margin a strongly elevated projecting ridge enclosing a certain basal area and joining another ridge at the humerus ; a postbasal ridge placed nearer the suture sending off a branch meeting the humeral ridge ; a postmedian outwardly curved ridge with a marginal smaller one forming a shallow concave area ; on the apical area a straight ridge sending off a branch meeting a marginal ridge ; parallel to the lateral margin runs a low ridge which becomes more elevated at the points of junction with other ridges. *Underside* finely shagreened. Legs shagreened and covered with shallow

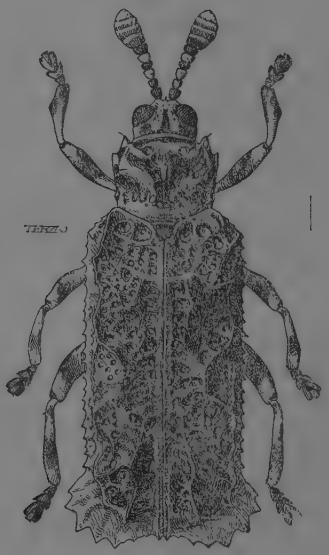


Fig. 4. *Octotoma tessellata*, sp. n.

pits and scattered over with white hairs ; front and middle tibiae short, the former with the outer apical margin excised ; claw segment of the tarsi not projecting beyond the previous segment ; claws strong.

*Length*, 4–5·5 mm.

Brazil : Bahia, on leaves of *Canavalia ensiformis* (*Dr. G. Bondar*).

*Type* in the British Museum.

Described from four examples, one of which is cleared and mounted in balsam.

The following combination of characters will differentiate this species from all others in the genus : (1) the chequered character of the colouration of the elytra ; (2) the parallel-sidedness of the elytra ; (3) the peculiar expansion of the apical margin of the elytra ; (4) the particular disposition of the elytral ridges.

**Anisostena fasciata,** sp. nov. (fig. 5).

Body oblong, parallel-sided; sides of prothorax without margin; each elytron with three ribs. Head with the vertex black mixed with a faint greenish tint; a narrow interantennal space and the clypeus piceous, but sometimes more brown; antennae black; pronotum brownish yellow with a faint smoky, shining, smooth spot in the centre and a small indistinct one on each side; scutellum piceous; elytra greenish blue, with the strongly developed first rib and a row of punctures on each side of it bright brownish-yellow, which stands out very prominently; underside brownish yellow, with a lateral patch on the sterna, the last one or two visible abdominal sternites, the points of articulation between the femora and tibiae, the apex of tibiae and the tarsi, piceous. The whole insect is subnitid.

*Head* with the vertex smooth, impunctate, but seen under a high power finely reticulate; interocular space with a median longitudinal impressed line. Antennae

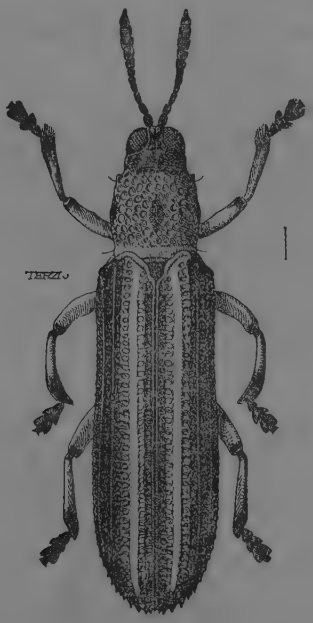


Fig. 5. *Anisostena fasciata*, sp. n.

hardly extending to the base of the pronotum; first and second segments about equal in length; third somewhat more slender than the preceding segments, longer than fourth; fourth and fifth about equal; sixth slightly shorter; surface of all segments rough and bearing a few scattered whitish hairs; from the seventh the segments form an elongate club, which is covered with pubescence; eighth, ninth and tenth about equal; eleventh bluntly pointed. *Prothorax* longer than broad, very slightly narrowed anteriorly and posteriorly; at each anterior lateral angle a little tubercle bearing a fine seta; the entire surface on the upper side is honeycombed with large deep pits, except in the centre; basal margin smooth, impunctate. *Scutellum* longer than broad, almost parallel-sided, with the apex truncate, and the base slightly wider than the apex; surface seen under a high power very finely

shagreened. *Elytra* broader at the base than the prothorax ; basal margin thickened ; between the suture and the principal rib two rows of deep squarish punctures, between the principal rib and the next two similar rows, again between the second and third ribs two rows and finally between the third and lateral margin two more rows, so that there are eight rows on each elytron ; on each side of the scutellum two punctures in a line may represent a scutellar row ; lateral margin serrated, the small spinules being placed rather far apart, but on the apical margin more closely placed, a few becoming larger ; at the apex the elytral margin somewhat expanded. *Underside* with a few punctures on sides of the sterna ; abdominal sternites very finely shagreened, with a few scattered whitish hairs ; mid-tibiae inwardly curved.

*Length*, 4·5–5 mm.

Brazil : Bahia, 1928, on grasses (*Dr. G. Bondar*).

*Type* in the British Museum.

Described from six examples.

The colour scheme, particularly the elytral stripes, is sufficient to differentiate this species from all its congeners.

**Cephalolia saccharina,** sp. nov. (fig. 6).

Body oblong, narrow, parallel-sided, with the apex not rounded as a whole, but each elytron rounded separately. General colour shining black, with about one-third of the basal area on the elytra yellow-brown ; the front edge and lateral edges of the prothorax very narrowly brown ; tarsi piceous.

*Head* with a small depression and a few scattered punctures on the vertex ; interocular space as a whole shallowly concave and more closely punctate. Eyes

Fig. 6. *Cephalolia saccharina*, sp. n.

not strongly convex. Antennae hardly reaching the base of the pronotum; first segment larger than second, punctate, with a few scattered whitish hairs; second also punctate and with similar hairs; from the third all the segments are thickly covered with brownish pubescence; third segment longer than fourth; fourth to tenth about equal to each other; eleventh somewhat longer and bluntly pointed. *Prothorax* quadrate, with the basal margin bisinuate, sides strongly but narrowly reflexed; posterior lateral angles acute, anterior rounded; upper surface convex from side to side, sparsely punctate, the punctures on the lateral area being stronger than those near the apex; besides these there are extremely minute punctures which can be seen only under a high power. *Scutellum* pentagonal, very finely shagreened, with the apex pointed. *Elytra* somewhat broader at the base than the prothorax; lateral margins reflexed, with the apical edge finely serrated. Each elytron with eleven longitudinal rows of punctures including a scutellar row. *Underside* covered with fine whitish pubescence.

*Length*, 5 mm.

Brazil: Bahia, on sugar-cane, 1928 (*Dr. G. Bondar*).

*Type* in the British Museum.

Described from four examples.

In form and colouration this species resembles *Cephalolia histrio*, Guér.; but differs in being narrower and more elongate in general form, in having the sides of the prothorax more parallel and the anterior lateral angles more rounded.

**Anoplitis canavaliae,** sp. nov. (fig. 7).

Body oblong, fairly broad, broadly rounded at apex, narrowed in front. General colour buff; the head sometimes piceous; eyes black; antennae deep pitch-brown; a median and a lateral stripe on the pronotum, a pattern on the elytra and the thoracic sterna deep red pitch-brown; the abdominal sternites somewhat darker brown than the upper side; the sutural and the external lateral angles of the elytra pitch-brown. Scutellum pitch-brown. The elytral pattern, roughly speaking, is an oblique cross placed more on the apical area than on the discal, the posterior arms of the cross extending to the external lateral angles of the elytra, but the fore-arms not reaching the elytral margins; behind the angle formed by the posterior arms of the cross the suture and the intervals between the ribs are diffusedly darkened. In the fore-arms of the cross only the intervals between the ribs are dark, but in the hind-arms both the ribs and the intervals. The suture is stained to a certain distance behind the scutellum.

*Head* narrowed in front, somewhat narrower than the front of the prothorax; interocular space not smooth, and with a median longitudinal impressed line, which is continued as a fine ridge between the antennae. Antennae about one-third the length of the body; first segment rounded, with the surface rough and having a few whitish hairs; second similar but smaller; third longer; fourth shorter than third; fifth slightly shorter than fourth and equal to sixth; from the seventh the segments form an elongate thickened club, more hairy and with the last bluntly pointed. *Prothorax* quadrate, narrowed in front; sides finely margined; basal margin bisinuate, somewhat depressed and deeply excavated in the middle; at each anterior lateral angle a little projection; upper surface completely and closely covered with large coarse punctures. *Scutellum* rectangular, longer than broad, finely shagreened. *Elytra* broader at base than the prothorax, sides somewhat concave behind the middle; lateral and apical margins serrate, the teeth not being close together; suture raised; each elytron with three strongly raised ribs, the third or that near the lateral margin bending round towards the suture and meeting the second and first ribs; the intervals between the suture and the first rib, between each pair of ribs and between the third and the lateral margin, each containing two longitudinal series of large and coarse

punctures, each pair of punctures being separated from the following pair by a slightly raised transverse rib. *Underside* somewhat shining, abdominal sternites finely shagreened; without hairs; tibiae without spines.

*Length*, 3·5 mm.; antennae a little more than 1 mm.

Brazil: Bahia, on leaves of *Canavalia ensiformis* (*Dr. G. Bondar*).

*Type* in the British Museum.

Described from seven examples.

The fairly broad character of the elytra and the particular elytral colour pattern are sufficient to distinguish this species from its congeners.

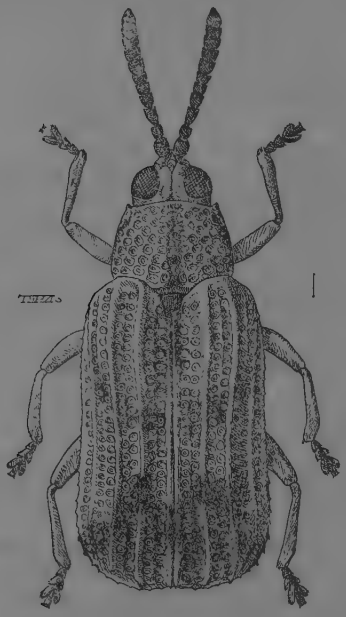


Fig. 7. *Anoplitis canavaliae*, sp. n.

*Canavalia ensiformis*, DC., popularly called Jack Bean or Sword Bean, is a native of the West Indies, but is cultivated in various parts of the Old World. It has been imported into Brazil, where it is also cultivated. *C. ensiformis* does not occur among the seven species of *Canavalia* enumerated in Martius' Flora Braziliensis.

Larva (fig. 8).

The larva is 4 mm. long (specimens in alcohol), and consists of thirteen segments including the head, three thoracic and nine abdominal segments. There are nine pairs of spiracles: a pair on the mesothoracic and on each of the first seven abdominal segments, and the last pair opening on the ninth, the eighth being without spiracles. The thoracic spiracles open laterally and the abdominal dorsally. The specimens preserved in alcohol are creamy white, except the head, which is dark brown. The three thoracic segments are the broadest, the last two abdominal segments being the

narrowest. The abdominal segments have a pointed projection on each side, those of the seventh and eighth being less pronounced and the ninth having none. The head is not that of a typical mining larva. It is convex above and composed of two large and laterally bent sclerites which are produced posteriorly into the prothorax. Two other sclerites with a narrow strip between them joining the larger sclerites form the dorsal surface of the head. The ventral is similarly formed by three sclerites, the intermediate one being larger. On the inner side of the maxillae are situated many papillae, and the labrum and labium both have a fringe of small papillae at the anterior edge. At each side anteriorly is an antenna (fig. 8, *b*), which

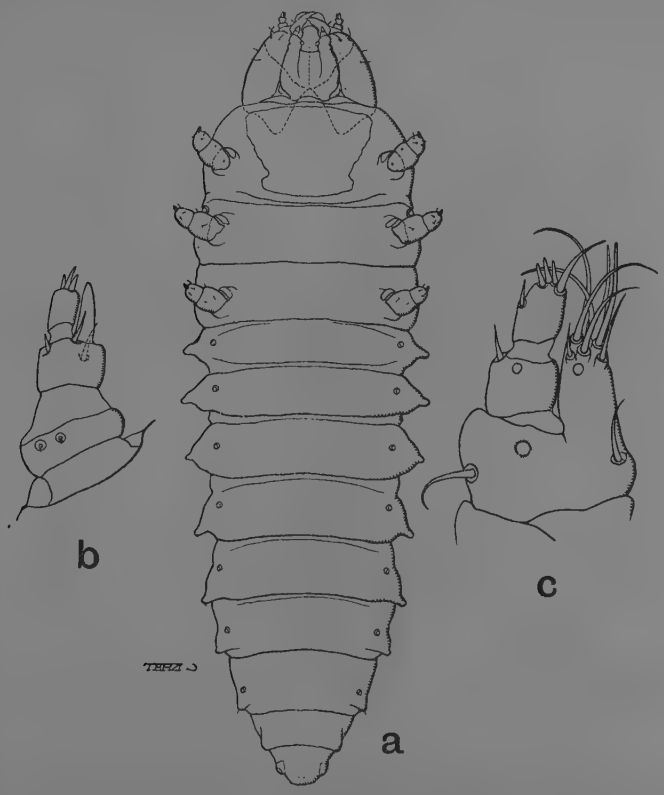



Fig. 8. *Anoplitis canavaliae*, sp. n., larva: *a*, ventral view, showing spiracles on dorsum as seen through the transparent preparation; *b*, antenna; *c*, maxillary palpus.

is three-segmented, the apical segment being small; internal to the latter is a bluntly pointed process. Each thoracic segment bears a well developed leg on the underside, consisting of a base and two segments surmounted by a claw, which is small compared with the size of the leg. The surface of the whole larval skin, both on the dorsal and ventral sides, is finely shagreened.

Judging from the structure, although the larva does not appear to be a true leaf-miner, it is probable that it lives under protection.

Pupa (fig. 9).

The pupa is about 3·5 mm. long (specimens in alcohol) and broader than the larva. The colour of specimens preserved in alcohol is dirty brown. It is more narrowed anteriorly than posteriorly. In a cleared specimen the head, antennae, and leg are seen through an enveloping sheath. There are nine abdominal segments, each having a spine on either side, and the ninth having four apical spinules ; the lateral spines of the seventh and eighth are much smaller than the others. Each of the first to fifth abdominal segments bears a pair of spiracles opening on the dorsal surface, those on the fifth segment being produced into conical spines. In the preparation examined the trachea is seen to go up the whole length of the spine (fig. 9, *c*). The dorsal surface of each of the second to sixth abdominal segments bears in two transverse lines ten distinct small hairs, the first line containing six and the second four. In the first the hairs are placed further apart than in the second, the lateral ones

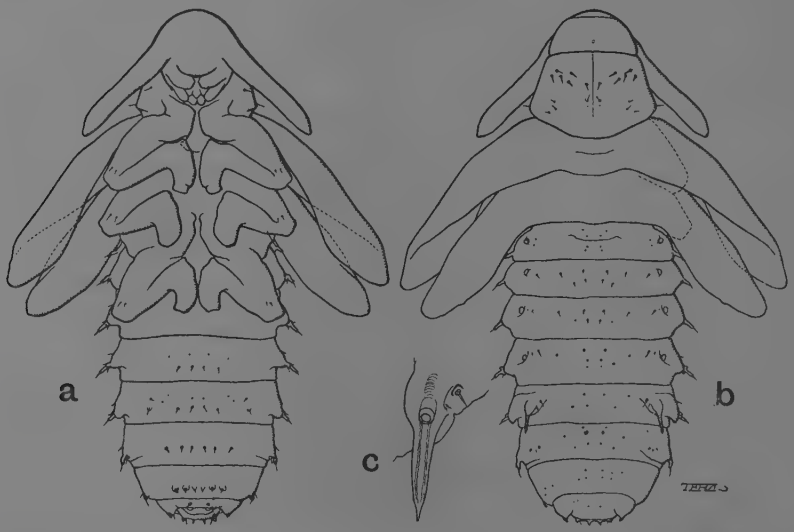



Fig. 9. *Anoplitis canavaliae*, sp. n., pupa : *a*, ventral view ; *b*, dorsal view ; *c*, conical spiracle, enlarged.

being near the spiracles. On the ventral surface of the seventh abdominal segment there is a group of similar small hairs arranged in a transverse line across the middle. The other segments also bear similar hairs ventrally, but not regularly arranged. Besides these hairs the whole surface has a shagreened appearance, owing to the presence of extremely minute hairs.

**Chalepus bondari,** sp. nov. (fig. 10).

Body oblong, somewhat narrowed in front, parallel-sided, rounded at the apex ; sutural angles not emarginate. Colour yellow and black, distributed as follows : head, antennae, a median longitudinal stripe on the pronotum, scutellum and a small area round it, a fairly large apical area on the elytra, lateral margin of the elytra expanding inwardly to the second rib and joining with apical patch only between

the second and third ribs, a broad patch on the prosternum, a large patch on the metasternum, all the abdominal sternites except the base of the first and a small lateral patch, apices of femora and tibia and tarsi, black; the rest of the body yellow. The black varies in intensity, being more pitchy in some parts.

*Head* cylindrical; vertex not convex, smooth, impunctate; interocular space slightly depressed, finely shagreened, and with a fine median longitudinal impression; without an interantennal projection; clypeus oblong, covered with whitish hairs; first segment of antennae broad, slightly angularly produced; second smaller, rounded; third longer; fourth shorter than third and equal to fifth; from the sixth the segments become thicker; seventh to tenth about equal in length; eleventh slightly longer and bluntly pointed; the whole antennae are covered with bristly

Fig. 10. *Chalepus bondari*, sp. n.

hairs. *Prothorax* longer than broad, somewhat narrowed anteriorly and posteriorly; sides rounded and extremely finely margined; excavated at the base in front of the scutellum; base of the elytra fitting into an undulation of the basal margin; upper surface somewhat convex and closely covered with fairly large circular pits and with a short fine longitudinal median impression. *Scutellum* oblong, with the apex rounded, surface somewhat convex, smooth, shining, impunctate. *Elytra* broader at the base than the prothorax; margins on each side of the scutellum thickened. Each elytron with three strongly raised ribs, suture raised but not so strongly, and with four pairs of longitudinal rows of deep squarish pits; three or four punctures may be said to represent a scutellar row; the walls of the pits are also raised, forming short transverse ribs; elytral margins serrate, the teeth at the apex being somewhat larger and alternating with smaller ones. *Underside* smooth and shining.

*Length*, 7 mm.; antenna, 2·5 mm.

Brazil: Bahia, 1928 (*Dr. G. Bondar*).

*Type* in the British Museum.

Described from one example.

From amongst those species belonging to the genus *Chalepus* having a similar coloration (that is, a certain distribution of yellow and black) this species can be distinguished by a combination of characters which will not be found together in any other species. These characters are: (1) the size; (2) the particular distribution of yellow and black on the elytra, though it must be remembered that it varies to a certain extent; (3) the relative size of the teeth on the apical margin of the elytra; (4) the fact that the sutural angles are not emarginate.

# NOTES ON THE SCARABAEID BEETLES ATTACKING VINES IN UKRAINE.

By N. S. Dekhtiarev,
*Central Station for the Protection of Plants in Ukraine.*

(Plates V & VI.)

The most favourable areas for the cultivation of grape-vines in Ukraine are the sands of the lower reaches of the Dnieper in the district of Kherson, the shore of the Black Sea, the Kherson-Odessa districts, and along the Sea of Asov, chiefly in the district of Mariupol. Moreover, as is well known, vines do not suffer from *Phylloxera* when grown on pure sand. For these reasons, numerous State Departments, and also many private individuals, have spent a great deal of money in utilising this enormous extent of shifting sands for growing grapes.

The unexpected appearance of the larvae of various Scarabaeid beetles, especially *Polyphylla fullo*, L. (fig. 1), has been a great obstacle to the successful exploitation of these barren spaces. The larvae in the soil generally average about 10–12 to the square metre, and they often completely destroy the newly planted vines in one summer. Many enterprising persons have thus been ruined in their endeavours to form vineyards on the sands. It was stated officially in pre-war times that these pioneers had spent over £2,000,000 sterling without any result.

The larvae of *Anoxia villosa*, F., *A. pilosa*, F., *A. orientalis*, Kryn., and *Anomala aenea*, DeG., are of much less importance, though they also gnaw the underground

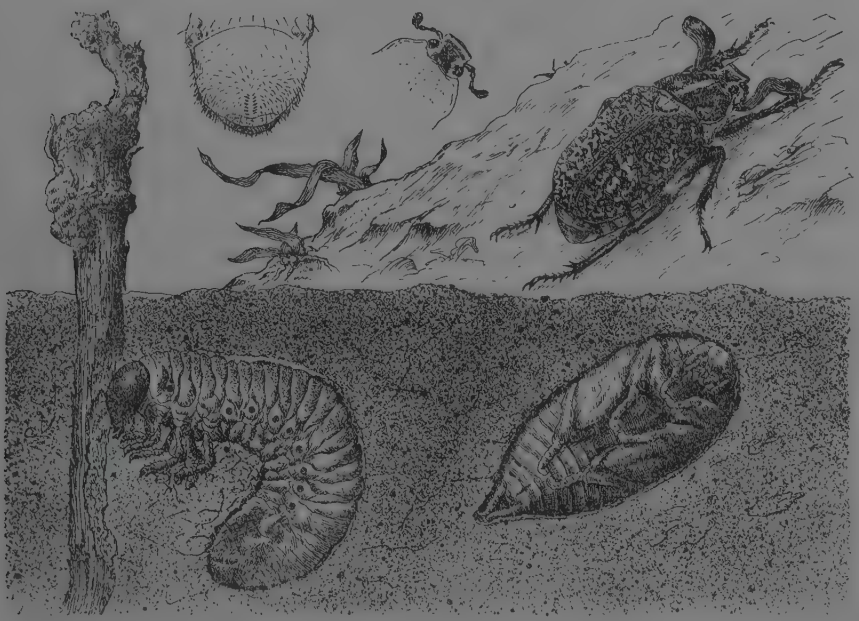


Fig. 1. *Polyphylla fullo*, L.: larva, pupa, and adult. Natural size.

parts of the vine plant. Those of *Pentodon idiota*, Hbst., *Melolontha hippocastani*, F., and *M. melolontha*, L., often appreciably injure grape roots in Ukraine on hard, black and clayey soils.

Notwithstanding the attacks of *Polyphylla fullo*, several persons have spent a great deal of money and effort in growing grapes on the sands and now have splendid vineyards. These growers adopted the method known locally as "fattening" the larvae. It consists in planting the young vines much more densely than is necessary and in replacing such as may be destroyed. Ultimately the surviving plants form the foundation of the vineyards; and although the vines are not in regular rows, yet such properties have yielded good profits. For many years of experience have shown that the larvae are not harmful to well established vines, and the beetles avoid laying their eggs on properly cultivated ground. It must be admitted, however, that this method was often found to be entirely ineffective. There are plots where it has been applied for twenty or more years, yet not a single plant has remained intact, and the ground has been ultimately abandoned. Such plots that are specially favourable for *P. fullo* larvae are often found in the middle of otherwise flourishing plantations; they are very convenient areas for experimenting on ways and means of combating this pest.

**Natural Enemies.**

An Asilid fly, *Satanas gigas*, Eversm., .is a very active predator of *P. fullo* and other Scarabaeid beetles on the sands.* This robber-fly is nearly the largest palearctic Dipteron. The female attains a length up to 45 mm., the male up to 40 mm. It is widespread over the eastern and south-eastern parts of Ukraine, but is exclusively found on sandy soils. It appears in greatest numbers in the hottest sunny weather at the end of June and in July. Unfortunately, the flies most often attack the males of *P. fullo* and other less harmful Scarabaeid beetles, such as *Anomala*, *Anoxia*, etc., owing to the fact that the females of *P. fullo* are comparatively inactive.

Oviposition by the females of *Satanas* may be easily observed under both natural and artificial conditions. Some of the flies were caught *in copula* and placed in suitable cages, and in one or two days the females began to lay their eggs. When laying, the female inserts almost the entire abdomen into the sand (fig. 2). Rarely more than 1–5 eggs are laid at one time. After this the female with characteristic movements of its abdomen smooths the surface of the sand, trying to give it an untouched appearance. The eggs are shining white, about 2 mm. in length and 1 mm. in breadth, and possess the quality of sticking to one another or to the sand grains. Under artificial conditions one female lays about a hundred eggs. The young larvae hatch in about 6–8 days and are then about 4 mm. in length and 0·5 mm. in width. They immediately burrow down into a deeper, damp layer of sand, where they feed by sucking the larvae of *P. fullo* and other Scarabaeid beetles. The adult larva attains a length of up to 55 mm. The pupae are 43 mm. in length, and are exceedingly active; they can work themselves up to the surface of the sand when the time arrives for emergence.

A Tachinid fly, *Microphthalma disjuncta*, Wied., is also a serious enemy of *P. fullo*, often destroying a considerable percentage of the larvae. Besides this, various other species of Tachinid flies and Hymenoptera (*Scolia* and *Tiphia*) are parasitic on *P. fullo*, but they are all much rarer than *M. disjuncta*.

Hedgehogs (*Erinaceus roumanicus*, Barret-Ham.) occur commonly and destroy many beetles in the evenings; they are particularly useful because observations have shown that impregnated females of *P. fullo* form a considerable part of their food.

* N. S. Dekhtiarev, "Materials for the biology of Ukrainian Asilids."—Protection of Plants in Ukraine, 1926, pp. 70–72 (in Ukrainian).

The mole (*Talpa europea brauneri*, Satun.), which is widely spread in Ukraine, is entirely absent from the sands of the Cherson district on the left bank of the Dnieper. It is just here that *P. fullo* does the greatest harm. The question of the artificial colonisation of the mole in this locality has been raised lately by Professor A. A. Brauner, of Odessa. In other districts of Ukraine, especially on the right bank of the Dnieper, the mole is not rare on the sands. It is the most active predator of *Polyphylla* and continues its useful work throughout the winter.

Fig. 2. *Satanas gigas* ovipositing ; diagrammatic.

## Measures of Control against the Beetles.

Hand collection of the adult beetles is undertaken on a large scale in Ukraine ; but the destruction of the males is not of much practical value, and the collection of the females is difficult owing to their retiring habits, for they usually bury themselves in the sand during the day. Other measures aim at preventing the beetles from laying their eggs on the plots, either by the destruction of weeds attractive to the females, or by the use of strong-smelling substances as deterrents. Good results have been obtained by the use of commercial naphthaline for this purpose, but it is much too expensive. Such substances as tar, creosote or phenol are more promising. These may be sprayed on the surface of the soil before the beetles begin to fly, or rags and sawdust soaked in them may be scattered on the plots.

## Hand-collection of Larvae.

This simple method of control is very generally adopted, being carried out either once, during the cultivation of the soil, or intermittently during the whole summer. In the latter case the young vines are regularly examined, and when signs of injury are noticed the soil is searched for larvae.

## Mechanical Obstructions.

Many attempts have been made to devise some mechanical protection for the vines by surrounding them, when planting, with pieces of coke, rough stones, broken shells, metal shavings, etc. We know cases in which a metal cylinder was used for this purpose, but it did not become very popular.

**Poison Baits.**

The use of wood shavings, bran and other materials soaked in poison and buried in the ground has given satisfactory results. It has long been known that *Polyphylla* will readily eat dry wood, such as the vine-props, and the larvae often show an actual preference for such food. This has led to the idea of trying to destroy them by means of poisoned sticks, which are prepared as follows: small branches are made into sticks about two feet in length and about as thick as a pencil or finger. Arsenic, Paris green, or some other suitable insecticide, is then mixed in hot water, and the sticks are well boiled in this solution, being afterwards driven into the sand round the vines. This method still needs study and verification; for it is clear that not all dead wood is eaten by the larvae with equal readiness. The most attractive wood is evidently that of fruit trees, then pine and poplar, and lastly oak and willow. Old brushwood, which has been lying about for a long time and is slightly decayed, also appears to be eaten readily. Moreover, the different effects of the various insecticides has to be taken into consideration, so that further experiments are necessary before the method can be recommended for general use.

**Carbon Bisulphide.**

The application of carbon bisulphide, alone or mixed with kerosene, has often been tried against Scarabaeid larvae with definite success. The chemical is applied by means of injectors, or else balls of tow are soaked in it and then buried in the soil. Unfortunately, both methods have proved too expensive under Ukraine conditions.

**Paradichlorobenzene (P D B).**

At last, thanks to the investigations of Professor Z. S. Golovyanko, paradichlorobenzene is now coming into use in Ukraine, having proved most successful in sandy areas, though in heavy soils the vapour cannot penetrate properly.

This chemical does but little injury to plants. On plots that have been heavily treated with it, herbage springs up and flourishes, and old grape vines have shown no reaction to the strongest doses even when placed quite near them. The young stocks are, however, more susceptible. A dose of 7 grammes placed at a distance of 1 inch causes burning, and the plant usually dies, but the same amount at a distance of 4 inches will cause no harm whatever; on the contrary, vines thus treated attract attention by their fine growth and intense green colour. (Pl. vi)

The optimum dose, and one that will usually kill 100 per cent. of the larvae, is 7 grammes of P D B to 4 square feet placed at a depth of 2–3 inches. The holes are, therefore, made 2 feet apart in both directions, with a vine in the centre of each square. Applied in this way about 240–300 lb. of P D B is required for an acre.

Undoubtedly this method of control is rapidly facilitating the effective cultivation of the sandy wastes in Ukraine.

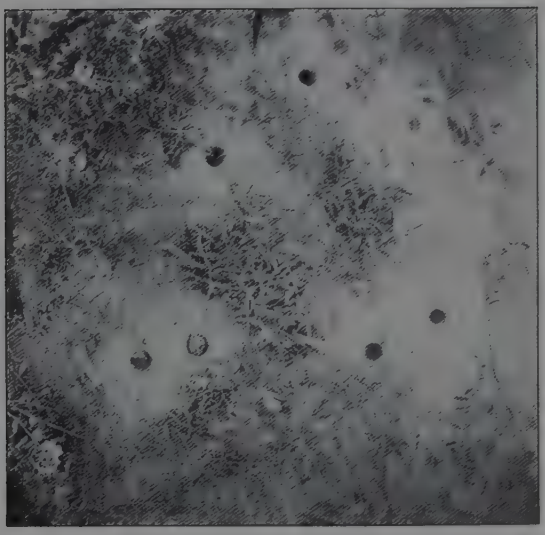


Fig. 1. Holes made by *Polyphylla fullo* when emerging from the soil for their evening flight.

Fig. 2. Pupæ of *Satanas gigas* (nat. size).

Fig. 3. *Satanas gigas*, ♂ (nat. size).

Fig. 1. An untreated experimental plot planted with young vines, all of which were destroyed by larvæ of *Polyphylla fullo*.

Fig. 2. A part of the same plot treated with paradichlorobenzene every plant is healthy and growing well.

# A NOTE ON THE USE OF DRIED POISON BAIT AGAINST LOCUSTS IN THE SUDAN.

By Harold H. King, F.L.S., F.E.S.,
*Government Entomologist, Anglo-Egyptian Sudan.*

There are in the Sudan three species of migratory locusts: *Anacridium moestum melanorhodon*, Walk., or the tree locust, *Locusta migratoria*, L., and *Schistocerca gregaria*, Forsk., sometimes termed the desert locust. Of these the last-named is the plague locust of the country—the other two species being relatively unimportant—and is the species referred to as the "locust" throughout this paper.

From 1899 till 1917 swarms of locusts occurred annually, but then followed a period of ten years during which the Sudan suffered no damage from this pest. In 1927 and again in the succeeding year the locust reappeared as a plague, and there is little doubt but that it is to be expected year by year over an extended period and until the cycle either naturally terminates or is artificially brought to an end. The swarms of fliers appear from May onwards and oviposit in July and August when and where in the arid regions sufficient rain has fallen, the resulting generation of adults emigrating in October. A certain amount of breeding takes place during the winter on the Red Sea littoral, where winter rains occur, but this district is relatively small and easily dealt with; the main problem is how to prevent breeding during the summer rainy season throughout the vast areas of the central and northern Sudan.

The type of country resorted to by the locust for breeding is that generally described as arid and semi-arid, very sparsely inhabited by nomad Arabs who grow but little grain, relying mainly on their flocks of sheep and herds of goats, cattle and camels, which range widely in search of grazing. The rainy season lasts about three months, and during this period an average of some six inches of rain may be expected. In effecting the control of locusts over some thousands of square miles of country of this nature, it is obvious that both the labour and transport required must be reduced to the minimum. The various mechanical methods of destroying hoppers are, therefore, unsuitable and recourse must be had to the use of poison. The transport available is, except in certain favoured districts, entirely by camel, and with a view to the application of a poison spray to vegetation on which hoppers feed, a type of pneumatic spraying machine was designed which was suited to animal transport. This spraying machine gave good results in the hands of intelligent operators, but when used by unskilled natives could not be considered entirely satisfactory. The best results were obtained from the use of poisoned bran bait, but here again unskilled natives could not be relied upon to mix the bait properly, and experience showed that we had not got a really satisfactory method of effecting the destruction of hoppers under the conditions described. Clearly what was wanted was a prepared poison bait which could be issued ready for use.

Initial experiments were carried out during the winter months of 1927–28 on the Red Sea littoral with a poison bran bait which had been sun-dried and required only moistening with water to be ready for distribution to hoppers. The results obtained were very promising, and consequently it was decided to give it a more extended trial during the rainy season of 1928. Twenty-six tons of the dried bait were prepared during the early summer, and practically the whole of it was used during the ensuing locust season. The reports received from those in charge of locust destruction in the field were universally favourable, and for the coming season poisoning by means of this dried bait will be the standard method adopted.

The poison incorporated in the bait is commercial arsenite of soda (80 per cent. $As_2O_3$), to which is added molasses. The stock solution is prepared by dissolving 168 lb. arsenite of soda in water and making up the solution to 22 gallons; to this is added 62 gallons molasses. This stock solution is diluted in the proportion of one part by volume to seventeen parts by volume of water; 9 gallons of the dilute solution contain, therefore, 1 lb. arsenite of soda.

In preparing the bait the bran is heaped on a cement floor and dilute poison solution added in the proportion of 12 gallons of the solution to 100 lb. bran. The bran is then thoroughly stirred and mixed by means of shovels until it is uniformly moist, when it is spread to dry in the sun. When dry it is passed through a coarse sieve to remove any lumps.

Men employed in mixing the bran and poison solution wear rubber boots to prevent their feet from coming into contact with the moist bran, and those engaged in pouring the poison solution are provided with motoring goggles to protect their eyes from splashes. All the men oil their hands and forearms before starting work to obviate the risk of arsenic being absorbed through the skin, and wash their arms and legs under supervision before leaving.

The dried bait is put up in strong cotton bags, each containing approximately 9¼ lb. The mouths of the bags are tied with fine cord and the bags packed in sacks, eight bags to a sack; the mouths of the sacks are securely sewn. Each bag bears on one side a representation of a locust in red paint and on the other the word *Hasharat* (the Arabic word for insects, used as the code word for the Entomological Section). Similarly each sack bears on one side the word *Hasharat* and on the other the words "Locust Poison," in Arabic characters. The weight of a sack containing eight bags of bait is 75 lb.; thirty sacks weigh 2,250 lb., or approximately one ton.

The contents of a bag (9¼ lb.) is in volume about two-thirds of a 4-gallon petrol tin, a vessel obtainable almost anywhere in the Sudan. The quantity of water required to moisten this amount of bait is one gallon, or three inches in depth in the tin. The width of the hand of the average native, measured across the middle knuckle-joint of the fingers, is approximately three inches. The instructions given to natives using the bait in the field are, briefly, as follows:—

"Oil the hands and forearms with any edible oil, whether vegetable or animal in origin. Cut a notch in a stick three inches from the end of the stick to be used in measuring the depth of water in the tin. Pour water into the tin until it is three inches deep in the tin and add the contents of one bag of bait. Stir until the bait is evenly moist, and leave for ten minutes to allow the bait to absorb the water and become soft. Then broadcast very thinly in the path of the advancing swarm of hoppers. In broadcasting, the bait should be thrown against the wind, when it will scatter well."

It will be noted that the proportion of poison to bran is high. British officials, as well as natives, using bait are, until they have had experience with it, sceptical as to its efficacy unless they can see the hoppers sicken, if not die, as a result of eating it. After ingesting the minimum lethal dose of arsenic, a well-grown hopper may live for up to three days, and men engaged in killing locusts in the desert cannot afford to wait more than a few hours. Further, it is desired to effect the destruction of the maximum number of hoppers with the minimum amount of bait, as the transport of the bait and of the water needed to moisten it is a heavy item. Dead and dying hoppers are devoured by their companions, and if their bodies contain sufficient arsenic, the cannibals in turn perish. It is believed that the risk of accidental poisoning of men and domesticated animals is not very materially greater than would be the case if the proportion of poison to bran were rather lower. The presence of molasses in the bait serves a two-fold purpose. Experience in the Sudan indicates that bran bait containing molasses is more attractive to locusts than bait prepared

of bran, arsenite of soda and water only, and, further, the molasses delays the drying up of the bait after it has been broadcast.

The results of experiments carried out to ascertain the relative attractiveness of freshly prepared bran bait and bran bait which had been stored for two months and then moistened indicated that the former was preferred by locusts. At the same time hoppers fed greedily on the latter, and it was noted that adults flying at not more than six feet from the ground would detect the presence of the moistened dried bait and settle to feed on it.

Attempts have been made to find some satisfactory but cheap material which would serve as a substitute for bran, but up to the present without success. To carry by camel for two or three hundred miles a bait which, though cheap, will give only say a 70 per cent. kill (taking bran to give a 100 per cent. kill) would be false economy, although such a bait might, under other conditions, be worth using.

As to the length of time sun-dried bait may be stored without suffering deterioration, bait which has been in store for ten months is still in good condition, and it is proposed to carry out tests with it year by year over a period of ten years.

The use of sun-dried poison bran bait is not restricted to the destruction of locusts. It has been employed with success against cutworms (larvae of *Agrotis ipsilon*, Hufn.) and should prove equally efficacious against field crickets and insects of similar habits.

Khartoum, 7th February 1929.

# NEW PARASITIC HYMENOPTERA AND NOTES ON OTHER SPECIES.

By D. S. Wilkinson,
*Senior Assistant, Imperial Bureau of Entomology.*

## Ichneumonidae.

**Eulimneria stellenboschensis,** Cam.

*Limnerium stellenboschense*, Cameron, Trans. S. Afr. Phil. Soc., xv, 1904, p. 200.

♀♂. Black ; mandibles (except at apices), palpi, the four anterior coxae (except basally), trochanters and trochantins of the four anterior legs, the hind trochantins, tibial spurs of the four posterior legs, tegulae, costal veins at base, white or nearly so ; basal three-fourths of the hind tibiae (except for a darkish area above in basal fourth), very pale reddish testaceous, approaching white ; the bases of the four anterior coxae, the femora and the tibiae and tarsi of the four anterior legs, the hind tarsal joints basally, pale red tetaceous ; hind femora (except at apex above, which is blackish), 1st tergite above at extreme apex, 2nd tergite in apical fourth and to some extent laterally, 3rd tergite in the greater part (except discally at base), succeeding tergites at least at apex, red or red testaceous ; hind trochanters red, darkened above ; flagellum varying from white to red testaceous below, and from red testaceous to black above ; wings slightly infumated ; stigma and wing veins dark brown (except possibly towards the base of the wing), the stigma with a testaceous cloud basally.

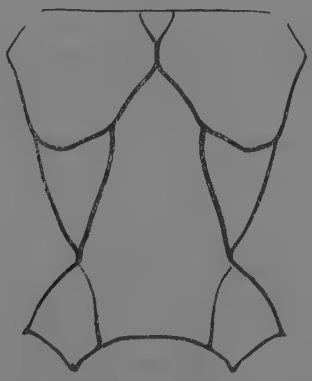


Fig. 1. *Eulimneria stellenboschensis*, Cam., areation of propodeon.

♀♂. *Head* minutely and closely coriaceous, with the clypeus across apex shining and smooth save for some minute punctures ; flagellum, in ♀ with 23–24 joints, usually the former, in the ♂ with 24–27 joints, usually 25 or 26. *Thorax* : mesonotum more strongly coriaceous than in the head, apparently impunctate ; the disc of the scutellum and the mesopleurae more weakly coriaceous and with minute, but definite, more or less evenly spaced punctation ; propodeon (fig. 1) minutely coriaceous, and, but not always, with some indefinite, minute punctures, except in the petiolar area which is rugose or at least more coarsely granulated than the remainder ; propodeon medianly in apical half weakly, but definitely, excavate, not strongly excavate. *Wings* : the 2nd transverse cubital, particularly in the ♂♂, commonly obsolete, often entirely wanting. *Abdomen* : postpetiole nearly as strongly coriaceous as the mesonotum, the succeeding tergites progressively more weakly coriaceous ; ovipositor sheaths as long as or longer than the hind femora.

*Length*, 5 mm.

Redescribed from the type, which is in the British Museum, and from 5 ♀♀, 15 ♂♂, Reduit, Mauritius, x.1928 (*W. H. Edwards*).

*Host.* The type, which comes from the Cape Colony, South Africa, is without host record; the series from Mauritius was bred from a species of the Gelechiid genus, *Phthorimaea* (presumably *Ph. operculella*), on tobacco.

There is certain individual variation in the areation of the propodeon and in the extent of the red testaceous colouration of the abdomen; the basal area of the propodeon, however, is invariably triangular, with the short median longitudinal carina at its apex invariably present.

This species has been redescribed in view both of the importance of the present host record, and of Cameron's mis-statements with regard to the areation of the propodeon.

*E. stellenboschensis* appears to be easily separable, apart from generic differences, from the other Campoplegid parasite of *Pthorimaea*, namely *Omorgus phthorimaeae*, Cushman (Proc. Ent. Soc. Wash., xvii, 1915, p. 138), a species that is unknown to me. Since *Limnerium* and its related genera are so poorly differentiated and have been so often misinterpreted, it is wise, in such cases as this, to compare specific differences. I am indebted to Dr. Ferrière for much assistance in assigning *stellenboschensis* to its correct genus.

**Mesochorus expolitus,** sp. n.

♀♂. Pale red testaceous to testaceous; mesonotum with lateral fourths, and with anterior half of the median third, the external areae and to a varying extent the basal area of the propodeon, about apical half of the hind coxae above, the apical half of the petiole, the 2nd tergite as in *M. ornatus*, Wilkn. (except that the black meets across the base and extends at least two-thirds distance along the lateral margins), apical half of the 3rd tergite, succeeding tergites above to a limited extent, hind femora along outer faces, about basal and apical fourth of the hind tibiae, black; ocelli in a black spot; flagellum, stigma, and wing veins red brown, the costal veins blackish.

♀♂. Agrees well enough with my description of *M. decoratus*, Wilkn., except as follows:—*Head*: face with transverse basal carinae V-shaped, and with a median longitudinal keel running almost to clypeus; lower facial orbits decidedly striate. *Thorax*: propodeon not so closely nor so strongly punctate throughout, the areola commonly almost devoid of punctation, and the dentiparal areae with widely spaced punctures; apical tooth of scutellum not apparent; propodeon with basal area and the areola as in *M. excultus*, Wilkn., except that the areola relatively is more elongate, with the petiolar area much as in *M. ornatus*, Wilkn., except that it is relatively broader; the costulae emitted from the middle of the areola as in *excultus*, longer than the greatest breadth of the areola, but shorter than the greatest breadth of the petiolar area. *Wings* with nervulus postfurcal. *Abdomen*: 2nd tergite at apex greater than median length, less than length of ovipositor sheaths, these latter shorter than the petiole; median length of 3rd tergite less than that of 2nd, this latter about equal to the male processes.

*Length*, 5·5 mm.

Uganda: Kampala, 3 ♀♀, 2 ♂♂, 1.ix.1928 (*G. L. R. Hancock*).

*Type* deposited in the British Museum.

*Host.* Recorded by Mr. Hancock as bred from an unidentified species of the Ichneumonid genus *Charops* parasitising the Nymphalid butterfly *Acraea acerata*, Hew.

This species runs to couplet 8 in my key to the African species of *Mesochorus* (Trans. Ent. Soc. London, lxxv, 1927, p. 69).

**Mesochorus concinnatus,** sp. n.

♀♂. Agrees in colour with *M. ornatus*, Wilkn., except as follows : Flagellum dull brown, more particularly towards apical half ; mesonotum with the testaceous median area darkened in anterior half, except along sides ; hind femora not at all darkened ; mesopleurae anteriorly and below, and the mesosternum, invariably strongly darkened to black ; the black normally, but not always, meeting across the base of the 2nd tergite, and the 1st tergite normally completely black.

♀♂. Agrees well enough in sculpture with my description of *M. ornatus* except as follows : *Head* : flagellar joints 28–31. *Thorax* : propodeon with apex of areola about three-fifths the greatest breadth of areola, and with the petiolar area not quite as broad at apex as its greatest breadth. *Legs* : hind coxa and trochanters together not longer than the petiole. *Abdomen* : petiole with breadth at apex about two-fifths its median length ; the small, deep impressions on each side of the post-petiole only present in the males ; 2nd tergite with median length about equal to apical breadth, somewhat longer than median length of 3rd tergite ; male processes longer than 3rd tergite.

*Length* averaging about 3 mm.

South Africa : Boksburg, Transvaal, 12 ♀♀ (one the type), 14 ♂♂, 1925–1926 (*Rev. D. P. Murray*).

*Type* deposited in the British Museum.

*Host* unknown ; recorded as bred from larvae of the Danaid butterfly, *Danais chrysippus*, L.

It is evident from this long series that it is not possible to rely for specific characters in this genus solely upon the carination of the propodeon. The areola in the above series is very variable, at times being short and stout, at times elongate, while in one or two instances the basal area is fused with the areola. The basal area also is variable ; normally acute at apex it becomes occasionally subacute or even, but very rarely, truncate. Despite this variability, however, there is no doubt but that this series runs in my key (Trans. Ent. Soc. London, 1927, p. 69) to *ornatus*, and that it is easily separable from this latter. The invariably darkened mesosternum is a substantiatory character of importance, despite the fact that certain colour variation also is noticeable—there is one specimen that has the scutellum entirely darkened.

Braconidae.

**Hecabalodes,** gen. n.

Subfamily Hecabolinae. Forewings with two cubital cells, the 2nd transverse cubital wanting ; the 1st cubital cell and the 1st discoidal cell separate, the 1st abscissa of the cubital vein complete ; radial cell complete, not reaching apex of wing ; nervulus present ; *nervus parallelus* interstitial ; 2nd abscissa of the cubital present. Hindwings in ♂ with stigma. Antennae with more than eleven joints. Abdomen with more than four visible tergites.

Genotype : *Hecabalodes anthaxiae*, sp. n.

This new genus differs from *Hecabolus* in that the radial cell does not reach the apex of the wing (thus agreeing with *Eucorystes*), and in that the *nervus parallelus* is interstitial. *Eucorystes* is easily separable, since it has the *nervus parallelus* not interstitial and the males without a stigma in the hind wings ; in *Ecphylus* the nervulus is absent. The remaining genera in this subfamily are easily separable

with the use of Szépligeti's generic table in the *Genera Insectorum*, in which are included, so far as I am aware, all the genera with the exception of *Polystenidea*; this latter has only four visible tergites.

**Hecabalodes anthaxiae,** sp. n.

♀♂. More or less opaque and dull red or red testaceous; ovipositor sheaths, ovipositor at apex, parastigma, and in the ♂ the stigma of hindwings, black, or at least strongly darkened; stigma of forewings with a hyaline cloud at base.

♀♂. Integument coriaceous throughout except possibly at extreme apices of the tergites, strongly coriaceous (or even granulated) on the head, mesonotum, scutellum, propodeon, hind coxae, and 1st tergite. *Head* cubical, with occiput definitely margined; ocelli small, their distance from the eyes considerably greater than the distance between the posterior pair; flagellum with about 18–25 joints. *Thorax*: notauli indicated anteriorly, otherwise absent; mesopleurae with a longitudinal sulcus below; scutellum quadrate, raised above the level of the mesonotum; propodeon, more particularly in the larger forms, with faint longitudinal carinulae, otherwise devoid of carination. *Wings* (fig. 2): forewings inserted at a point midway

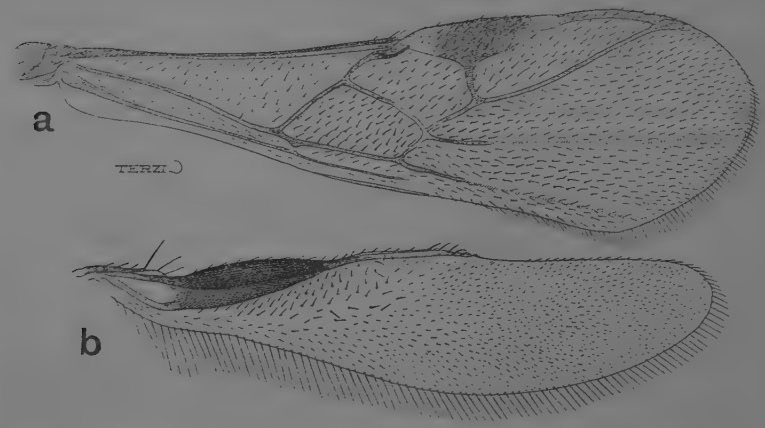



Fig. 2. *Hecabalodes anthaxiae*, gen. et sp. n.: *a*, forewing of ♀ and ♂; *b*, hind wing of ♂.

between the apex of the pronotum and of the propodeon. *Legs*: femora short and thick; tibial spurs minute; middle tarsi shorter than middle tibiae; hind coxae basally below somewhat produced into an angle. *Abdomen*: 1st tergite with median length about 1·2 times as great as apical breadth, this latter greater than basal breadth, longitudinally carinulate, in about the basal third with a raised area which occupies the median third and is bounded on each side by a carina; 2nd tergite longer than the 1st, carinulate in basal half, on each side with a transverse, rather sinuate sulcus situated at or shortly before the middle; succeeding tergites definitely transverse except the 6th in the ♀, which is much longer than those immediately preceding; 7th tergite in ♀ decidedly protruding; ovipositor and sheaths elongate, longer than the abdomen.

*Length* variable: ♀, 3·5–6·0 mm.; ♂, 3·0–4·0 mm.

British Sudan: Khartoum, 11 ♀♀, 4 ♂♂, xii.1927 (*H. W. Bedford*).

*Type* deposited in the British Museum.

*Host.* Bred from the Buprestid beetle, *Anthaxia congregata*, Klug, infesting a branch of *Acacia arabica*.

**Fornicia ceylonica,** Wilkinson (1928).

While my paper was in the press, but too late to make any alterations, I received a letter from Mr. S. *F.* Light in which he states that he had wrongly identified the host of this parasite as the Limacodid moth *Spatulicraspeda castaneiceps*, and that he now realises that the host must have been young larvae of *Natada nararia*, also a Limacodid, which was the only other species he procured at that time.

**Apanteles papilionis,** Vier.

*Apanteles* (*Protapanteles*) *papilionis*, Viereck, Proc. U.S. Nat. Mus., xlii, no. 1,888, 1912, p. 145.

*Apanteles agamemnonis*, Wilkinson, Bull. Ent. Res., xix, 1928, p. 81 (*syn. nov.*).

During the course of the preparation of a paper that I hope to publish presently on the Ethiopian species of *Apanteles*, I became aware that I was unable to separate *pallidocinctus*, Gahan, from what I had previously understood was *papilionis*, Viereck. After consultation with Dr. Gahan, however, who was good enough not only to examine the three species concerned but also to present to the British Museum, through the Imperial Bureau of Entomology, paratypes both of *pallidocinctus* and of *papilionis*, it has become apparent that the two specimens from which I made my redescription of *papilionis* (in my paper on the Indo-Australian species) had been wrongly identified as such, being in fact *pallidocinctus*, and that *agamemnonis* was synonymous with *papilionis*. This synonymy, therefore, is published herewith, and the record of *papilionis* from Kenya Colony, East Africa, must be cancelled, together with the record of the host in that locality ; it should be noted, in addition, that my redescription of *papilionis* is, in fact, a redescription not of this species but of *pallidocinctus*.

I have received from Dr. C. F. C. Beeson a series of *A. papilionis* from the Khasi Hills, Assam, 2.vi.1927 (*M. Bose*).

**Apanteles belliger,** sp. n.

♀♂. Black ; scape, mouth-parts, tegulae, tibial spurs, all legs and 1st tergite (except as below), basal ventrites, lateral membranous margins of the 1st and 2nd tergites, red testaceous ; flagellum deep red brown ; hind tarsi and apex of hind tibiae slightly darkened ; 1st tergite along extreme lateral margins, and in apical third or fourth, strongly darkened to black ; stigma and most wing veins red brown.

♀♂. *Head* : face punctate (degree 2) ; toruli large, in the ♀ about equidistant from the face and the apex of the clypeus, in the ♂ rather nearer to the latter ; clypeus not differentiated ; posterior ocelli possibly rather nearer to each other than to the eyes, the distance between them about equal to the diameter of one. *Thorax* : mesonotum and disc of scutellum with widely spaced minute punctation (degree 2) ; propodeon smooth save for a few large but indefinite punctures (degree 3–4). *Wings* : venation rather variable ; the length of the transverse cubital commonly equal to, and as commonly longer than, that of the 1st abscissa of the radial (with a stump or swelling at their point of junction), the latter equal to the recurrent, twice as long as the upper portion of the basal vein, longer than the pigmented portion of the 2nd abscissa of the cubital which is longer than the apical portion of the 1st abscissa of the cubital ; stigma shorter than metacarp, its breadth between about 1·28 and 1·5 times as great as the length of the recurrent. *Legs* : hind coxae elongate, reaching almost to apex of 3rd tergite, basally above with strong, but not well defined, punctures ; the longer hind tibial spur four-fifths, and the shorter spur about a half,

the length of the basal joint of the hind tarsus. *Abdomen*: 1st tergite parallel-sided or nearly so (except at extreme apex which narrows slightly), with its median length twice its breadth, smooth and shining except along extreme lateral margins and in apical third or fourth where it is indefinitely slightly rugose; 2nd tergite with the median length about equal to or just a little greater than the basal breadth, half the apical breadth, with the apex arcuately emarginate, and with, extending from base to apex, a raised, convex, parallel-sided, area (in breadth one-third of the basal breadth of the tergite), on each side of and at the base contiguous with which is a broad, more or less straight, discal sulcus which does not reach the apex of the tergite and which, in fact, is commonly almost punctiform, the tergite otherwise unsculptured save for sparse minute punctation and some indefinite weak rugosity; 3rd tergite longer than 2nd, with only sparse minute punctation, like the succeeding tergites; ovipositor sheaths short, the hypopygium more or less acute.

*Length*, 2.25 mm.

MAURITIUS: St. Pierre, 10 ♀♀, 14 ♂♂, xi.1927 (*D. d'Emmerez de Charmoy*).

*Type* deposited in the British Museum.

*Host*. Recorded as parasitic on the Army Worm, the Noctuid, *Cirphis unipuncta*, Haw.

*Cocoons*. Apparently solitary (one mounted separately with each specimen), straw-coloured.

This species runs with *A. aristolochiae*, Wilkn., in my revised key, from which, however, it is clearly distinct if only on account of the 2nd tergite.

**Apanteles flavipes**, Cam.

*Cotesia flavipes*, Cameron, Mem. Proc. Manch. Phil. Soc., (4) iv, 1891, p. 185.
*Apanteles nonagriae*, Olliff, Agric. Gaz. N.S. Wales, iv, 1893, p. 381 (*syn. n.*).
*Apanteles flavipes* (Cameron), Wilkinson, Bull. Ent. Res., xix, 1928, p. 93.
*Apanteles nonagriae* (Olliff), Wilkinson, Bull. Ent. Res., xix, 1928, p. 136.

I have not seen Olliff's type, but I have received from Mr. W. A. McDougall from Queensland, Australia, a series, bred from the Noctuid *Phragmatiphila truncata*, Walk., that is undoubtedly *nonagriae*, Olliff; these are not separable from *flavipes*, Cam. The Australian ♀♀ that I have seen have the antennae apparently just slightly longer than the Indian and Formosan forms.

**Apanteles ruficrus**, Hal.

*Microgaster ruficrus*, Haliday, Ent. Mag., ii, 1835, p. 253.
*Apanteles antipoda*, Ashmead, Proc. Linn. Soc. N.S. Wales, xxv, 1900, p. 355 (*syn. n.*).
*Apanteles antipoda* (Ashmead), Wilkinson, Bull. Ent. Res., xix, 1928, p. 95.
*Apanteles ruficrus* (Haliday), Gahan, Bull. Ent. Res., xix, 1928, p. 256.

It was Dr. A. B. Gahan, I believe, who first came to a decision with regard to the synonymy of *antipoda* and *ruficrus*; I see no reason to disagree, although neither of us has seen Haliday's type. *A. ruficrus* would now appear to be cosmopolitan, or nearly so.

I have received from Gatton, Queensland, Australia, a series of 39 ♀♀, 7 ♂♂, 3.xii.1925 (*Ballard*), which was bred from larvae of the Noctuid moth *Heliothis armigera*, Hübn. (= *obsoleta*, F.). The cocoons of this series are in a mass, as in *glomeratus*, and are dirty white to pale grey.

Dr. Gahan has recorded this species from the Sudan from a borer, probably *Sesamia cretica*, Led., and I have before me, from Khartoum, a series of 4 ♀♀, 1 ♂, 2.xii.1926 (*H. B. Johnston*), also from a Lepidopterous borer, and 1 ♀, 1 ♂, 28.xi.1928 (*R. C. Darling*) bred from the Noctuid *Cirphis loreyi*, Dup.

I have also received a series from Coimbatore, South India, of 5 ♀♀, 1 ♂, 3.iii.1923 (*Ramachandra Rao*) which had been bred from a species of *Phytometra* (*Plusia*).

The Australian series above referred to has the 3rd and 4th tergites almost invariably, and the 5th and 6th sometimes, completely red testaceous; there are commonly indications of darkening, however.

**Apanteles paludicolae,** Cameron (1909).

I have received from the Sudan a series of 14 ♀♀, 20 ♂♂, 10.ii.1927, 11.xi.1927, 11.ii.1928, bred from the Pterophorid moth, *Sphenarches caffer*, Zell. *A. paludicolae*, which Cameron originally described from a Pterophorid, has, till now, been recorded, so far as I am aware, only from the type locality, Ceylon. The Sudanese material agrees perfectly with Cameron's darker forms, *all* the specimens having darkened hind femora.

**Apanteles taprobanae,** Cameron (1897).

A series has been received from Coimbatore, South India, of 4 ♀♀, 2 ♂♂, 22.x.1923 (*Ramachandra Rao*), bred from *Stauropus*. This series exhibits the weak sculpturing of the Indian form of the species.

**Apanteles malevolus,** sp. n.

♀♂. Black; scape, flagellum basally to some extent, mouth-parts (except palpi which are pale), tegulae, legs (except as follows), basal ventrites, red or red testaceous; coxae for the greater part black, commonly reddened at apex; tibial spurs reddened; flagellum apically, stigma, and metacarp, brown; costal veins testaceous; hind tarsi commonly slightly darkened.

♀♂. *Head*: face punctate (degree 2); flagellum, of ♀ short and stout, not longer than the combined lengths of the thorax and abdomen, of ♂ noticeably longer and more attenuated. *Thorax*: mesonotum with strong, well separated, possibly rather shallow, punctures (degree 3–5); disc of scutellum indefinitely punctate (degree 1 or 2); propodeon with a definite median longitudinal carina from which on each side oblique carinae run upwards and join a strong transverse basal carina, the transverse basal carinae normally considerably stronger than the others. *Wings*: the 1st abscissa of the radial and the transverse cubital equal in length, shorter than the breadth of the stigma, longer than the recurrent; metacarp barely longer than, or more usually equal to, the length of the stigma. *Legs*: hind coxae shining, basally above with strong, definitely separated punctures (degree 4), on outer faces also strongly punctate, but more weakly and more sparsely; the hind tibial spurs equal, half the length of the basal joint of the hind tarsus. *Abdomen*: the three basal tergites in shape extremely like those of *taprobanae*, Cam.; 1st tergite coarsely rugoso-punctate in apical half; 2nd tergite longitudinally rugulose, more weakly sculptured than the 1st tergite, apparently without lateral sulci; 2nd suture strong; 3rd tergite sometimes with indefinite sculpture in basal fourth, otherwise unsculptured; ovipositor sheaths short.

*Length*, 2·0–2·5 mm.

India: Dehra Dun, United Provinces, 29 ♀♀, 13 ♂♂, 2.x.1927—2.xi.1927, 15.x.1928 (*S. N. Chatterjee*).

*Type* deposited in the British Museum.

*Host*. Recorded by Dr. Beeson as parasitic on larvae of the Noctuid moth, *Hyblaea puera*, Cram., defoliating *Tectona grandis*.

*Cocoons* white or very pale greenish, gregarious.

A species very like *taprobanae*, Cam. (to which it runs in my keys) but easily separable on the venational characters, the colour of the tegulae, and the relative length of the flagellum (also compare *radiantis*, sp. n.).

**Apanteles radiantis**, sp. n.

♀♂. Black ; tegulae, the four anterior legs, red or red testaceous, often somewhat darkened in places ; hind femora, hind tibiae, and hind tarsi, strongly darkened, but not black, the femora often with some red colouration ; tibial spurs pale ; stigma and wing veins light red brown, the costal veins, upper margin of stigma, and metacarp, much darker, almost black.

♀♂. *Head* minutely punctate (degree 1), shining. *Thorax* : mesonotum, particularly in posterior half, strongly and closely punctate (degree 5), the punctures so close as to form almost a reticulate appearance ; lateral fourths of mesonotum almost smooth ; disc of scutellum with some strong punctures ; mesopleurae anteriorly with strong close punctation, posteriorly entirely smooth ; mesosternum indefinitely punctate ; propodeon rugose, with a weak, but definite, median longitudinal carina, and with rather weak transverse basal carinae, these latter, however, on account of the rugosity often very indistinct or absent. *Wings* virtually as in *A. ruficrus*, Hal. (*antipoda*, Ash.), normally, but not invariably, with the transverse cubital longer than the 1st abscissa of the radial, and the pigmented portion of the 2nd abscissa of the cubital almost as long as the apical portion of the 1st abscissa. *Legs* : hind coxae indefinitely punctate ; hind tibial spurs equal, equal to or rather longer than half the basal joint of the hind tarsus. *Abdomen* : 1st tergite closely resembling that of *ruficrus* only not so coarsely rugose ; 2nd tergite with more or less weak longitudinal striae, which are marked more strongly at extreme base and which towards the lateral margins of the tergite are very commonly entirely absent ; 2nd suture fine ; 3rd tergite definitely considerably longer than the 2nd (20:14), unsculptured, as are the succeeding tergites ; ovipositor sheaths short.

*Length*, 2·0–2·3 mm.

AUSTRALIA : Gatton, Queensland, 4 ♀♀, 3 ♂♂, 3.xii.1925 (*E. Ballard*).

*Type* deposited in the British Museum.

*Host*. Bred from larvae of the Noctuid moth, *Euxoa radians*, Guen., attacking cotton seedlings.

*Cocoons* dirty pale grey, heaped indiscriminately together.

A species with general facies extremely like that of *ruficrus*, but differing markedly in the sculpture of the hind coxae, in the relative lengths of the 2nd and 3rd tergites, and in the colour of the hind femora. *A. radiantis* runs in my revised key to *australiensis* and *deliadis*, or, according to the strength of the transverse basal carinae, to *taprobanae* and *malevolus*, sp. n., from all of which it is clearly separable by the colour of the hind femora and by the relative lengths of the 1st abscissa of the radial and the transverse cubital veins.

**Apanteles grandiculus**, sp. n.

♀. Black ; mouth-parts, legs (except coxae and as below), tegulae, costal veins, red or red testaceous ; the hind tarsi, apices of hind tibiae, margins of stigma, more or less of a darker red, opaque, tinged with brownish ; metacarp quite dark ; stigma discally hyaline ; palpi and tibial spurs pale, slightly tinged with red.

♀. *Head* obscurely punctate. *Thorax* : mesonotum punctate (degree 3 about), more closely so anteriorly, the punctures (particularly posteriorly) more or less aciculated ; disc of scutellum punctate down the sides (degree 2–3) ; propodeon obscurely punctate in basal half, aciculate in apical half, medianly entirely smooth

except at extreme apex, with the areola apparently not even indicated. *Wings*: the recurrent, the apical portion of the 1st abscissa of the cubital, and the transverse cubital, all about equal, longer than the pigmented portion of the 2nd abscissa of the cubital which is equal to the upper portion of the basal vein, shorter than the breadth of the stigma, which is less than the length of the 1st abscissa of the radial, this latter about 1·8 times as long as the pigmented portion of the 2nd abscissa of the cubital; stigma shorter than metacarp. *Legs*: hind coxae on outer faces minutely punctate, basally above finely rugose; the longer hind tibial spur half, and the shorter spur three-tenths, the length of the basal joint of the hind tarsus. *Abdomen*: 1st tergite strongly arched, with a smooth tumescence medianly, finely aciculate and with some indefinite punctures along the sides and to some extent, but very obscurely, discally in apical half, otherwise smooth and highly polished, with the basal breadth about three-fourths the median length and about 1·66 times the apical breadth, the sides more or less regularly converging; 2nd tergite with some obscure punctures across extreme apex at sides, virtually entirely smooth, apparently without lateral sulci, and with the apex strongly rounded, the breadth of apex at least 2·33 times but not more than 2·66 times the median length, this latter about equal to or rather less than the apical breadth of the 1st tergite; 3rd tergite with median length twice that of 2nd tergite; hypopygium acute, produced; ovipositor sheaths longer than the combined lengths of a hind tibia and a hind tarsus.

*Length*, 4 mm.

INDIA: Shillong, Assam, 2 ♀♀, viii–x.1919 (*T. B. Fletcher*).

*Type* deposited in the British Museum.

*Host*. Recorded as a parasite on a Lepidopterous borer in *Rubus*.

*Cocoons* unknown.

This species runs in my key to *calycinae* (hind femora not darkened), from which it is easily distinguished, if only on the colour of the tegulae.

**Apanteles leptoura,** Cameron (1909).

Mr. Bainbrigge Fletcher has been kind enough to supply me with some information with regard to the host of this species. His letter to me reads as follows:—"*A. leptoura*, Cam., if I remember aright, was bred by me from a larva boring in *Erythrina* stems and which at the time I took to be a Tortricid. I think, however, there is no doubt but that the true host is *Terastia meticulosalis* (Pyraustidae) which is a common borer in *Erythrina* shoots and which I did not know at that time. It would be as well to add a note to this effect to the type specimens."

*T. meticulosalis*, Guen., is almost cosmopolitan; it is not known, I believe, in the Palaearctic and Nearctic regions, however.

**Apanteles importunus,** Wilkinson (1928).

I have received from Dr. Gardner, from Dehra Dun, United Provinces, India, a series of 3 ♀♀, 2 ♂♂, 1 ?, 10–13.iii.1928, 2 & 5.viii.1928 (*S. N. Chatterjee*), which was bred from larvae of the Pyralid moth, *Nephopteryx rhodobasalis*, Hmps. This is the first specific host record for this species.

**Apanteles sagax,** sp. n.

♀. Black; the front femora (except basally), the middle femora at extreme apex, the tibiae and tarsi of the four anterior legs, the basal third of the hind tibiae, basal fourth of the basal joint of the hind tarsus, red (or reddish) testaceous; middle tibiae somewhat darkened at apex; palpi and tibial spurs pale; tegulae and costal

veins testaceous, the latter darkening towards stigma ; wings hyaline, the parastigma, stigma, metacarp, and the radial, transverse cubital, and the 2nd abscissa of the cubital, brown, remaining veins colourless or nearly so.

♂. Agrees with the description of the colour of the ♀ except as follows :—Middle tibiae nigrescent ; stigma hyaline, bordered round extreme margins, the border above dark, almost black, the two lower borders reddish brown ; metacarp reddish brown, remaining veins completely colourless.

♀. *Head* minutely punctate ; clypeus definitely differentiated ; toruli rather nearer to apex of clypeus than to eyes ; posterior ocelli rather nearer to each other than to eyes. *Thorax* : mesonotum weakly punctate (degree 3), almost rugose or rugosely striate along the lines of the notauli, aciculate posteriorly ; disc of scutellum smooth and shining, with a few minute punctures ; areola of propodeon extending from base to apex, in basal half deeply impressed and with its margins rugose, in apical half normal, acutely U-shaped, with the carinae well marked ; propodeon otherwise entirely unsculptured, shining, save for some minute punctures. *Wings* : venation somewhat variable ; the breadth of the stigma 1.33 times as great as the length of the recurrent, which is 1·5 times as long as the pigmented portion of the 2nd abscissa of the cubital, this latter shorter than the apical portion of the 1st abscissa of the cubital and about equal to the upper portion of the basal vein ; the radial and transverse cubital variable, often equal to each other, in which case they are each somewhat longer than the recurrent, and often with the radial equal to the breadth of the stigma, in which case the transverse cubital is rather shorter than the recurrent ; stigma shorter than metacarp. *Legs*: hind coxae on outer faces with sparse minute punctation, basally above possibly rather more strongly and closely punctate ; the longer hind tibial spur rather more than half, and the shorter spur about three-eighths, the length of the basal joint of the hind tarsus. *Abdomen* : 1st tergite with median length rather more than twice basal breadth, parallel-sided for about the basal seven-tenths, then narrowing evenly to the apex, which is rather broader than half the basal breadth, strongly arched, somewhat tumescent medianly, in basal half smooth, in apical half indefinitely rugoso-striate with a median, discal, shallow, longitudinally oval depression ; 2nd tergite with basal breadth half apical breadth and about 1·6 times median length, with well marked, strongly diverging, more or less straight, lateral sulci, which are somewhat longer than the median length, more or less unsculptured as are the succeeding tergites ; 3rd tergite with median length about 2·75 times that of 2nd tergite ; hypopygium acute and much drawn out, membranous and extensible along the longitudinal median line ; ovipositor sheaths just longer than the hind tarsus.

♂. Agrees well enough with the description of the sculpture of the ♀ except that the 1st tergite is more evenly narrowed to apex and not or hardly parallel-sided, and that the 2nd tergite is relatively rather longer.

*Length*, 2·5 mm.

TANGANYIKA TERRITORY : Morogoro, 8 ♀♀ (one the type), 1 ♂, 29.vii.1922 (*A. H. Ritchie*). UGANDA : 32 ♀♀, 4 ♂♂, undated (*G. L. R. Hancock*).

*Type* deposited in the British Museum.

*Host*. Both series were bred from the Pyralid moth, *Sylepta derogata*, F.

*Cocoons* unknown.

This *Apanteles*, although at first sight remarkably like *syleptae*, Ferr., is in fact not closely related to this latter species, which, comparatively recently, has been described from the same host ; *sagax* runs in my revised key to *calycinae*, Wilkn., from which it is obviously distinct.

**Apanteles mendosae,** sp. n.

♀♂. Black; all femora, tibiae, and tarsi (except that the hind tarsi and the apices of the hind tibiae are darkened somewhat), and scape (except at apex), red testaceous; the flagellum red-brown to black, the darker colouring towards the apex, and often almost testaceous basally; palpi and tibial spurs pale; costal veins testaceous; stigma light brown to red-brown.

♀♂. *Head*: vertex and face minutely punctate (degree 1). *Thorax*: mesonotum with well separated, more or less evenly spaced punctures (degree 4); disc of scutellum indefinitely punctate, more definitely punctate along the sides (degree 3), often apparently entirely impunctate; areola large, open at extreme base, its carinae and the costulae well marked; propodeon otherwise unsculptured, shining. *Wings*: venation in many respects much resembling that of *A. prodeniae*; the transverse cubital about equal to the recurrent, shorter than the 1st abscissa of the radial, this latter about equal to or rather shorter than the breadth of the stigma; the upper portion of the basal vein half the length of the recurrent, rather shorter than the apical portion of the 1st abscissa of the cubital, this latter equal to the pigmented portion of the 2nd abscissa of the cubital; stigma shorter than metacarp. *Legs*: hind coxae on outer faces with some minute punctation; the longer hind tibial spur about half, and the shorter spur about two-fifths, the length of the basal joint of the hind tarsus. *Abdomen*: 1st tergite, arched, shining, and more or less smooth, with apical breadth about two-thirds the median length (relatively rather longer in the ♂) and a little greater than basal breadth, with the sides apparently somewhat sinuate, so that towards the base the tergite is somewhat narrower than at the base, and towards the apex somewhat broader than at apex; 2nd tergite parallel-sided, the apex straight, and with the median length about half the apical breadth of the 1st tergite, with the lateral sulci wanting or just apparent at extreme base, and with the integument unsculptured, as the succeeding tergites; 2nd suture more or less obsolete; hypopygium acute, produced; ovipositor sheaths about equal in length to hind femora.

*Length*, 2·75 mm.

Federated Malay States: Kuala Lumpur, 3 ♀♀, 2 ♂♂, and 5 ? (abdomen missing), 11.i.1927 (*G. H. Corbett*).

*Type* deposited in the British Museum.

*Host.* Recorded as a parasite of the Lymantriid, *Dasychira* (originally *Orgyia*) *mendosa*, Hübn.

*Cocoons* unknown.

This species runs in my revised key to *prodeniae*, from which it is easily separable by the colour of the scape and shape of the 2nd tergite.

**Apanteles taragamae,** Viereck (1912).

I have received from Mr. Ramachandra Rao, of Coimbatore, a series of 1 ♀, 3 ♂♂, bred at various localities in South India from the Xyloryctid (Tineidae), *Nephantis serinopa*, Meyr.

**Opius phorelliae,** sp. n.

♀. Black; head (except ocellar area and apices of mandibles), prothorax, mesonotum, tegulae, mesopleurae above and to a certain extent immediately above the insertion of the coxae and along the sulcus, scutellum, metanotum, metapleurae, legs (except tarsi), ovipositor, red testaceous; palpi and tarsi darkened; wings hyaline; stigma black; wing veins dark brown to black (except those of the hind wing, and, in the forewing, the 1st abscissa of the medial and the basal half of the 1st abscissa of the anal).

♀. *Head*: face with some punctures, and with a raised, median, longitudinal area and keel much as in *O. afreutretae*; facial depressions absent or vestigial; occiput margined as in *O. afreutretae*; flagellum with 28–29 joints, the 2nd not longer than the 1st; vertex and cheeks with only minute punctures. *Thorax*: mesopleurae (except in the testaceous areas), mesonotum, and disc of scutellum, entirely impunctate and highly shining; notauli punctiform; mesopleural sulcus usually crenulate; propodeon rugoso-reticulate, with a strong median longitudinal carina in basal half. *Wings*: the recurrent, which is 1·66 times as long as the 1st abscissa of the radial, received into the 2nd abscissa of the cubital, the basal portion of which is about half the length of the nervulus, this latter, postfurcal by its own length, equal to the 1st abscissa of the radial but rather shorter than the 2nd transverse cubital; the 2nd abscissa of the radial less than half as long as the 3rd abscissa, 1·47 times as long as the 1st transverse cubital, twice as long as the breadth of the stigma, this latter twice as great as the length of the nervulus; 3rd abscissa of the cubital pigmented only in about basal half to third. *Abdomen*: 1st tergite faintly indefinitely rugose, with a longitudinal carina towards each side; succeeding tergites polished and shining, each with one or two transverse rows of minute punctures; ovipositor sheaths definitely longer than abdomen, the hypopygium acute.

*Length*, 2·5 mm.

South Africa: Petronella, Transvaal, 1 ♀ (*type*), and 4 of indeterminable sex (*abdomen missing*), xi.1928 (*H. K. Munro*).

*Type* deposited in the British Museum.

*Host.* Labelled as parasites of fully-grown larvae of the Trypetid fly, *Phorellia peringueyi*, Bez.

A species apparently closely related to *O. vittator*, Brues, even to colouring, but on account of its colouring otherwise very distinctive. *O. vittator* has, *inter alia*, the ovipositor only as long as the abdomen, while there are differences in colouration particularly in the mesonotum and mesopleurae. I have not seen Brues' species.

## COLLECTIONS RECEIVED.

The following collections were received by the Imperial Bureau of Entomology between 1st January and 31st March, 1929, and the thanks of the Managing Committee are tendered to the contributors for their kind assistance :—

Prof. H. A. Ballou :—12 Rhynchota ; from Trinidad.

Mr. P. J. Barraud :—137 Diptera, 26 Coleoptera, and 10 Rhynchota ; from the Punjab, India.

Dr. G. Bondar :—2 Diptera and 193 Coleoptera ; from Brazil.

Dr. P. A. Buxton, London School of Tropical Medicine :—59 Tabanidae, 2 Hippoboscidae, 2 *Lyperosia*, and 39 other Diptera ; from various localities.

Chief Entomologist, Pretoria :—206 Coleoptera, 403 Parasitic Hymenoptera, and 32 Rhynchota ; from South Africa.

Mr. L. D. Cleare, Junr., Government Entomologist :—2 Diptera, 60 Coleoptera and 9 early stages, 5 Lepidoptera, 3 species of Aphidae, 150 other Rhynchota, 20 Mallophaga, and 120 Ticks ; from British Guiana.

Prof. T. D. A. Cockerell :—29 Diptera, 64 Coleoptera, 17 Hymenoptera, 55 Lepidoptera, 3 Isoptera, 15 species of Coccidae, 87 other Rhynchota, 3 Orthoptera, 4 Chrysopidae, 2 Odonata, 11 Spiders, 3 Centipedes, 10 Millipedes, 3 Crustacea, and 2 Shells ; from various localities.

Mrs. Connal :—2 Culicidae ; from Southern Nigeria.

Mr. G. H. Corbett, Government Entomologist :—127 Diptera, 119 Coleoptera, 136 Parasitic Hymenoptera, 5 other Hymenoptera, 163 Lepidoptera, 126 Rhynchota, 13 Orthoptera, and 2 Planipennia ; from Malaya.

Mr. H. S. Cunningham, Plant Pathologist :—9 Coleoptera ; from Bermuda.

Mr. A. Cuthbertson :—5 Culicidae, 10 Tabanidae, 86 other Diptera, 3 Parasitic Hymenoptera, and 29 Rhynchota ; from Southern Rhodesia.

Dr. A. Dampf :—200 Curculionidae ; from Mexico.

Director of Veterinary Services, Pretoria :—52 Coleoptera and 3 larvae, 3 Rhynchota, 7 Orthoptera, 3 Collembola, 20 Mites, 9 Millipedes, 5 Earthworms, and 5 Crustacea ; from South Africa.

Mr. W. H. Edwards :—30 Parasitic Hymenoptera and 15 Lepidopterous larvae ; from Mauritius.

F. M. S. Museums, Kuala Lumpur :—398 Curculionidae ; from Malaya and British North Borneo.

Mr. C. Franssen :—7 Coleoptera and 42 Parasitic Hymenoptera ; from Java.

Mr. J. G. H. Frew :—145 Tabanidae, 65 *Glossina*, 39 Simuliidae, and 11 other Diptera ; from Sierra Leone.

Mr. J. C. M. Gardner, Systematic Entomologist :—255 Parasitic Hymenoptera, 94 Curculionidae, 2 Lepidoptera, and 8 Psyllidae and 40 nymphs ; from the United Provinces, India.

Mr. P. v. d. Goot :—2 Diptera, 18 Coleoptera, and 9 Lepidoptera ; from Java.

Government Entomologist, Lyallpur :—10 Diptera, 76 Coleoptera, 45 Parasitic Hymenoptera, 2 other Hymenoptera, and 2 Rhynchota ; from the Punjab, India.

Mr. W. Greenwood :—67 Parasitic Hymenoptera, 24 Lepidoptera, and 2 Trichoptera ; from the Fiji Islands.

Mr. W. B. Gurney, Government Entomologist :—6 Curculionidae ; from New South Wales, Australia.

Mr. G. L. R. Hancock, Assistant Entomologist :—150 Culicidae, 28 other Diptera, 324 Parasitic Hymenoptera and 200 cocoons, 384 other Hymenoptera, 30 Lepidoptera, 88 Rhynchota, 2 Orthoptera, and 9 Odonata ; from Uganda.

Mr. E. Hargreaves, Government Entomologist :—16 Diptera, 22 Coleoptera, 200 Parasitic Hymenoptera, 126 other Hymenoptera, 16 Lepidoptera, 66 Thysanoptera, 31 species of Coccidae, 3 species of Aphidae, 48 other Rhynchota, 7 Orthoptera, 3 Planipennia, and 5 Mallophaga ; from Sierra Leone.

Mr. G. H. E. Hopkins, Assistant Medical Entomologist :—5,000 Siphonaptera ; from Kenya Colony.

Inspector General of Agriculture, Baghdad :—100 Mites ; from Iraq.

Mr. R. W. Jack, Chief Entomologist :—17 Parasitic Hymenoptera ; from Southern Rhodesia.

Mr. L. G. E. Kalshoven :—32 Curculionidae ; from Java.

Prof. C. R. Kellogg :—80 Parasitic Hymenoptera ; from China.

Dr. W. A. Lamborn, Medical Entomologist :—5 Culicidae, 2 *Haematopota*, 2 Hippoboscidae, 110 other Diptera and 62 early stages, 217 Parasitic Hymenoptera, 20 Lepidoptera, 2 species of Coccidae, 2 Nemopteridae, and 18 Ticks ; from Nyasaland.

Dr. D. D. McCarthy :—55 Culicidae, 2 *Tabanus*, 63 Hippoboscidae, 99 other Diptera, 3 Coleoptera, 7 Hymenoptera, 4 Rhynchota, 2 Orthoptera, and 2 Ticks ; from Pemba Island, East Africa.

Mr. G. A. Mavromoustakis :—12 Hymenoptera ; from Cyprus.

Mr. J. E. M. Mellor :—32 Parasitic Hymenoptera ; from Uganda.

Dr. D. Miller, Government Entomologist :—12 Coleoptera and 6 Hymenoptera ; from New Zealand.

Mr. L. Moritz :—109 Orthoptera ; from Persia.

Mr. H. M. Morris, Government Entomologist :—6 Hippoboscidae, 25 other Diptera, 162 Coleoptera, 4 Chalcididae, 110 other Hymenoptera, 27 Lepidoptera, 31 Rhynchota, and 32 Orthoptera ; from Cyprus.

Mr. J. Muggeridge :—5 Coleoptera, 4 Parasitic Hymenoptera, and 1 species of Coccidae ; from New Zealand.

Mr. H. K. Munro :—2 Diptera ; from Portuguese East Africa.

Dr. J. G. Myers :—54 Diptera, 2 Coleoptera, 371 Parasitic Hymenoptera, 38 other Hymenoptera, 115 Lepidoptera and 14 early stages, and 4 Rhynchota ; from Trinidad.

Natal Museum, Pietermaritzburg :—1 Reduviid ; from South Africa.

Dr. A. A. Ogloblin :—181 Orthoptera ; from the Argentine Republic.

Mr. R. W. Paine :—30 Culicid early stages, 84 other Diptera and 3 puparia, 212 Coleoptera and 34 early stages, 374 Parasitic Hymenoptera, 212 other Hymenoptera, 17 Lepidoptera and 35 early stages, 2 species of Coccidae, 24 other Rhynchota, 9 Ticks, 30 Mites, and 2 Spiders ; from the Fiji and Solomon Islands.

Prof. E. B. Poulton, F.R.S. :—41 Parasitic Hymenoptera ; from Greenland.

Mr. Y. Ramachandra Rao, Government Entomologist :—6 Coleoptera and 41 Parasitic Hymenoptera ; from South India.

Mr. A. Reyne : 13 Coleoptera and 3 species of Coccidae ; from the Dutch East Indies.

Mr. A. H. Ritchie, Government Entomologist :—6 Diptera ; from Tanganyika Territory.

Mr. J. I. Roberts :—9 Rhynchota ; from Southern Rhodesia.

Dr. G. Russo :—45 Coleoptera ; from the Dominican Republic.

Dr. G. Salt :—25 Coleoptera and 3 microscope preparations ; from Tropical America.

Dr. H. Schouteden :—8 Siphonaptera and 1 species of Coccidae ; from Belgian Congo.

Mr. S. H. Skaife :—213 Orthoptera ; from South Africa.

Mr. F. E. V. Smith :—21 Coleoptera ; from Jamaica.

South African Museum, Cape Town :—151 Orthoptera ; from South Africa.

Mr. E. R. SPEYER :—2 Hymenoptera, 19 Orthoptera, and 2 Millipedes ; from Tunisia.

Mr. C. B. SYMES, Medical Entomologist :—90 Culicidae, 180 larvae, 120 other Diptera, 5 Anoplura, 105 Ticks, and 112 Mites ; from Kenya Colony.

Mr. F. H. TAYLOR :—3 Culicidae ; from Queensland, Australia.

Mr. T. H. C. TAYLOR :—4 Diptera, 21 Coleoptera, and 11 Lepidoptera ; from Trinidad.

Dr. P. TCHORBADJIEV :—6 Coleoptera, 156 Parasitic Hymenoptera, and 5 Psocidae ; from Bulgaria.

Mr. R. VEITCH, Chief Entomologist :—17 Parasitic Hymenoptera and 1 species of Aphidae ; from Queensland, Australia.

Mr. V. N. WEBER :—253 Orthoptera ; from Turkestan and Transcaucasia.

WELLCOME TROPICAL RESEARCH LABORATORIES, KHARTOUM :—300 Diptera and 75 early stages, 332 Coleoptera, 1,512 Parasitic Hymenoptera, 230 other Hymenoptera, 41 Lepidoptera, and 99 Rhynchota ; from the Sudan.

Mr. C. B. WILLIAMS :—81 Diptera ; from Tanganyika Territory.

Mr. G. N. WOLCOTT :—75 Coleoptera, 12 Hymenoptera, and 2 Rhynchota ; from Peru.

Dr. F. ZACHER :—34 Coleoptera ; from various localities.

# TWO GALL MIDGES (*CECIDOMYIDAE*) FOUND IN STORED PRODUCTS.

By H. F. Barnes, B.A., Ph.D.,
*Entomological Department, Rothamsted Experimental Station.*

The first species to be dealt with was received from M. Prosper Bovien, of the Statens Plantepatologiske, Forsøg, Lyngby, in October 1927. It was reared from larvae and pupae found abundantly among seed of radish (*Raphanus sativum*) that had been in storage for months, and it was thought that the larvae were preying on the mites (*Aleurobius*, etc.) which attack the seed. In a later letter it was stated that some years previously the midges were observed emerging in January from seed in which there were no *Aleurobius* but numerous *Cheyletus*. The midge occurs at irregular intervals in seed from Denmark, as well as in seed from Germany.

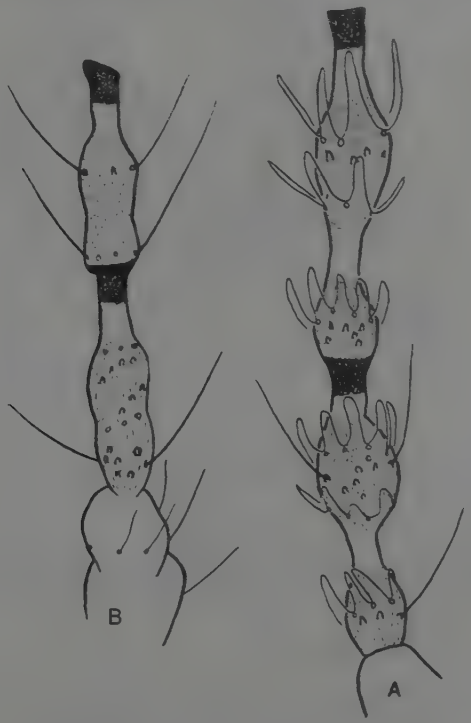



Fig. 1. *Lestodiplosis raphani*, sp. n., 1st and 2nd flagellar segments of antennae: A, male; B, female.

The midge belongs to the genus *Lestodiplosis*, whose larvae are well known to feed on the larvae of other gall midges. The species is new to science, and is described below.

**Lestodiplosis raphani,** sp. n.

*Male.* Length nearly 2 mm. Antennae nearly as long as the body; 2+12, 1st

(4808) Wt P5/3521 1,100 8/29 H & Sp Gp 52 

and 2nd flagellar segments fused (fig. 1, A), stem and neck of 1st flagellar segment slightly longer than broad, distal half of neck of 1st flagellar segment and basal portion of basal enlargement of 2nd flagellar segment dark, distal halves of necks of remaining flagellar segments dark ; loops of circumfila moderately long. Palps : basal segment small quadrate, second about twice as long as broad, third slightly narrower than second but same length, about twice as long as first segment, terminal segment slightly longer than third. Thorax dark brown dorsally. Wing speckled, circular dark patch at proximal end of 5th vein, irregular H-shaped dark patch with cross-bar of H along centre of upper fork of 5th vein, bases of H down distal ends of each fork, upper parts of H reaching across 3rd vein to costa, dark long hairs on dark patches, lighter long hairs on remainder of wing, speckling variable in area and intensity. Legs hairy, claws moderately curved. Genitalia (fig. 2) : basal clasp segment narrow, elongate

Fig. 2. *Lestodiplosis raphani*, ♂, ventral view of genitalia (setae omitted from one side).

oblong with basal setose lobe, thickly clothed with setae, distal clasp segment long, narrow ; dorsal lamella broad, deeply emarginate, each lobe rounded ; ventral plate broadly rounded ; style long, stout.

Cotypes, Cecid. 913–916, 1184–1189 inclusive.

*Female.* Length about 2 mm. Antennae (fig. 1, B) with distal halves of necks dark as in males, neck of 1st flagellar segment slightly more than twice as long as broad. Speckling on wings darker than in males on the average. Ovipositor lamelliform. Otherwise about as in male.

Cotypes, Cecid. 917–921, 1190–1195 inclusive.

Larvae, Cecid. 911, 912.

Habitat, stored seed of *Raphanus sativum* from Denmark and Germany, possibly feeding on mites.

The second midge was received from Dr. Guiseppe Candura, who stated that he found examples of it in flour at Naples and, since the flour was attacked by mites, he believed the larvae were feeding on the mites. The specimens were first sent to Dr. Felt for identification who said that they were a typical species of the genus *Arthrocnodax*, Rübs., and referred Dr. Candura to the present writer for determination of the species.

The specimens were not received in very good condition ; nevertheless it has been possible to determine that they belong to an undescribed species, which is now described.

**Arthrocnodax farinicola,** sp. n.

*Male.* Length 1 mm. Antennae about as long as the body, thickly haired; 2+12, 1st and 2nd flagellar segments (fig. 3, A) fused, stem of 1st flagellar segment slightly broader than long, neck about as long as broad, stem and neck of 3rd flagellar segment

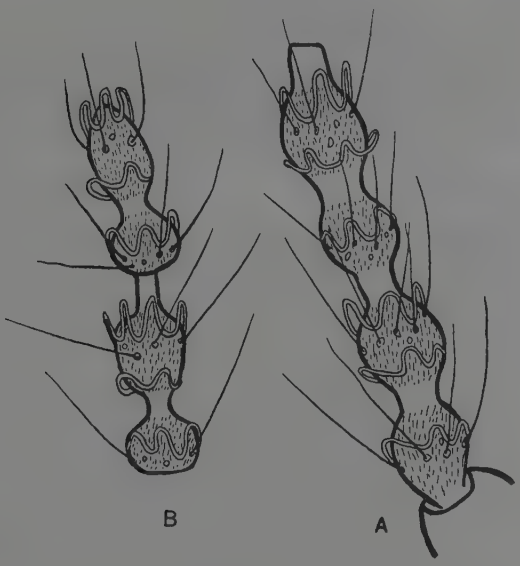



Fig. 3. *Arthrocnodax farinicola,* sp. n., ♂, flagellar segments of antennae : A, 1st and 2nd ; B, 11th and 12th.

about equal in length, stem about as long as broad, neck slightly longer than broad ; loops of circumfila moderately short. Palps : basal segment small quadrate, 2nd and 3rd about equal in length, twice as long as 1st, 3rd slightly more swollen than 2nd and

Fig. 4. *Arthrocnodax farinicola,* ♂, ventral view of genitalia.

4th, distal segment one-third longer than 3rd, distal three segments all with long dark hairs. Thorax dark brown dorsally. Wings hyaline, 3rd vein reaching margin of wing just before apex; costa, subcosta, 3rd vein and posterior margin of wing with moderately long hairs. Legs brown, hairy; claws moderately curved. Genitalia (fig. 4): basal clasp segment stout with basal lobe, distal clasp segment short, stout, swollen basally, both with setae; dorsal lamella broad, emarginate, lobes broadly rounded; ventral plate long, narrowly rounded; style long, pointed, narrow triangular.

Cotypes, Cecid. 1349–1357 inclusive.

*Female.* Length 1·25 mm. Antennae slightly longer than thorax, neck of 1st flagellar segment broader than long, basal enlargements with 2 irregular rings of long stout setae. Palps, proportions as in male. Ovipositor short, bilobed; otherwise as in male.

Cotypes, Cecid. 1358–1364 inclusive.

Pupa, Cecid. 1365.

Habitat, flour in Naples, probably feeding on mites.

# THE LOCUST INVASION OF PALESTINE DURING 1928.

By G. E. Bodkin, B.A., Dip. Agric. (Cantab.),
*Government Entomologist, Palestine.*

(Plates VII–IX.)

The object of this paper is to place on record, with as much detail as possible, a scientific and official account of this year's locust invasion and also to describe methods of control which were found to be, or thought likely to prove, efficacious. Thus in future years reliable information may not be lacking with regard to these very important points. It should be added that the paucity of previous scientific records concerning locust invasions of Palestine during earlier periods has proved a not inconsiderable handicap from a number of different points of view.

## Previous Locust Invasions.

It is possible to go back in history as far as 1491 B.C.[1] to find a record of a locust invasion in this part of the world. Later information [2, 3, 4, 5] states that Palestine was invaded by this same species of migratory locust* in the years 1865, 1878, 1890, 1902, 1915. The regularity of such invasions is phenomenal, for a study of these dates indicates an unvarying period of 12–13 years elapsing between each visitation. I have taken considerable pains to gather evidence from some of the oldest inhabitants in various parts of this country with regard to previous occurrences of locust trouble. The terrible visitation during the dark days of 1915 will remain vividly impressed in the memories of all who had the misfortune to be resident in Palestine at that period. It appears that on this occasion winged swarms of vast size came into Palestine from two directions, one part arriving in South Eastern Palestine from the direction of Egypt, over Sinai, and the other along the Mediterranean littoral and settling in the Jaffa district. These swarms gradually spread all over the country. Mating of the sexes took place immediately on arrival, which was half way through the month of March and early in April. Egg-laying commenced eight days after arrival of the swarms. A recent article on this event which appeared in the local press[6] may be quoted here :—

" Climatic conditions being extremely favourable for the development of the eggs, these hatched twenty-four days after being laid. The appearance of the whole country was that of a huge black carpet, and as the locusts advanced in age they became more voracious, more devastating, attacking in preference to all others the young citrus leaves, the vineyards, apricot and almond trees.

"Finding no sustenance on the uncultivated land they made straight for the green spots in ' armies ' often several kilometres long and many tens of metres wide."

The consensus of opinion seems to bear out the fact that only once in a generation do the swarms of migratory locusts appear in such numbers as to cause a national catastrophe like that of 1915, and I have been unable to secure definite evidence from any inhabitant of this country of an invasion during their life-time similar in magnitude to that one. The invasions of 1902 and 1890 were apparently comparable with that of this year (1928), *i.e.*, by comparison with 1915 of a minor nature yet serious enough to cause grave damage if not promptly and energetically dealt with. There would appear to be complete justification for the expenditure of large sums of money every eleven years on making all possible arrangements for satisfactorily dealing with large swarms of winged locusts and their progeny. History, in this

* The so-called Nejdian type, or desert locust, identified by Mr. B. P. Uvarov as *Schistocerca gregaria*, Forsk.

particular instance, undoubtedly repeats itself. The matter of insurance against loss from locust invasions might also receive the attention of cultivators.

**Economic Loss due to Previous Invasions.**

It is hardly necessary to enlarge upon these points but it may be recorded that the damage to the agriculture of the Jaffa district of Palestine alone, from locusts in 1915, has been modestly estimated at, approximately, £200,000. The damage to the whole country must have reached a colossal figure, as destruction was universal. There are to-day many orange groves in this country which have not yet fully recovered from the locust onslaught of 1915. To such economic loss must be added the adverse moral effect on the population of a wide-spread locust invasion. Such effect can only be really understood and appreciated by those who have witnessed the terrible spectacle of the all-devastating and relentless advance of immense swarms of young crawling locusts and the spirit of hopelessness and helplessness imbued thereby—the slow but sure destruction of the source of livelihood, the work of years undone in a few short hours.

Curiously enough it was that other destroyer, war, which in 1915 alleviated to no mean extent the economic loss and fear of famine which followed the locust invasion, for shortly after the visit of these destructive insects came the occupation of Palestine by the British Army, which brought with it large supplies of food and paid generously for all services rendered.

**Arrival and Distribution of the Winged Swarms in 1928.**

Following the incidence of locust swarms in the neighbouring countries of Sudan, Egypt, and Transjordan which commenced with the presence of migratory locusts in the Sudan during 1927, followed by the arrival of sexually immature locusts in upper Egypt during the latter half of October and early part of November in the same year, the advent and movements of similar large swarms in Transjordan throughout the months of February and March 1928, the appearance of very large swarms in Syria during the latter part of March in this year, Palestine was first invaded by a swarm of practically sexually mature locusts of unknown dimensions which passed over Jericho in a westerly direction during the night of the 25th March. Their presence was detected by large numbers approaching a powerful 'Lux' lamp around which a wedding festival was in progress. This swarm appears to have scattered widely over the country, for during the early days of April small numbers of migratory locusts were reported from different parts of the country. These were sufficient, however, to arouse the population of the country to a state of considerable excitement and nervous apprehension ; small numbers of dragonflies on the wing were confidently reported as vast swarms of locusts ; a few true migratory locusts which were sufficiently unwise as to descend in one small town were there caught by the police and triumphantly, yet quite seriously, reported as having been arrested. The price of several staple commodities of food rose appreciably.

On the 16th and 17th April 1928, large swarms of locusts were reported in the vicinity of the Allenby Bridge over the Jordan River but on the Transjordanian side of the stream. During the evening of the 16th, a swarm settled for the night in the vicinity of Jericho but left the following day. On the following day, at 2 p.m., large numbers of locusts were observed flying over Jerusalem in a south-westerly direction at a great height in the air ; the movement lasted for two hours. Swarms of locusts arrived from the south, in the Jordan valley, between the Jordan and Jericho on the 19th. Some of these were destroyed by means of hand collection and flame guns, the most notable one being a swarm densely covering some 12 acres of land.

Fig. 1. Map of Palestine showing places (marked in stronger type) where locusts appeared during 1919.

These locusts were sexually mature. For the next ten days swarms continued to arrive in this area, varying in size, but none larger than the one above estimated; numbers of them were completely or partially exterminated by field companies stationed in the district.

In continuation of the sequence of events there may now be quoted the bulletins which were issued by the Department of Agriculture at regular intervals. These bulletins were drafted at the headquarters of the Department of Agriculture in Jerusalem and were based on verbal, telephonic or telegraphic advice received either from members of the Entomological Section, the district stations of the Agricultural Department, or from members of the Police and Administration Departments.

" 24.iv.28. The swarm of locusts reported from Jericho and the Shuneh Valley (Transjordan) on 20th instant passed northwards up the Jordan Valley and was reported from Jenin, Beisan, Jisr Majamieh, Tiberias and Safad on the evening of 21st instant. It was engaged at all the above-mentioned points on the morning of the 22nd instant, and the survivors passed north-westwards towards the Lebanon on the line Safad-Rameh with flanking swarms as far west as Acre. Negligible damage has been inflicted on crops."

" 25.iv.28. The main swarm under reference in yesterday's report passed out of Palestine into the Lebanon on 22nd instant. At 5 p.m. on the same day a report was received from the Assistant Superintendent of Police, Gaza, that very extensive swarms were covering the whole belt of sand-dunes from Khan Yunis to Gaza. These are probably the swarms referred to on the 21st instant as passing westward over Amman and Zirka (Transjordan). Mobilisation of village labour is proceeding and Field Companies are being despatched from Jaffa to the most heavily infested areas."

" News of large flying swarms invading the sand-dunes between Khan Yunis and Gaza was confirmed on the morning of the 23rd instant. Three Field Companies arrived at Gaza with equipment early in the morning and all available village labour has been conscripted."

" 24.iv.28. A small swarm of locusts was destroyed on the 23rd instant, ten kilometres south of Haifa. This was apparently a remnant of the main swarm reported to have passed northward into the Lebanon on the previous day. A small swarm was destroyed with flame-guns by the Jericho Field Company at Ain Sultan during the night of 23rd–24th instant. Earlier reports from Gaza of extensive swarms between that town and Khan Yunis would appear to have been much exaggerated. The whole area was examined on 23rd instant and only a few scattered locusts were discovered. Fellahin reported that one swarm had been driven out to sea and drowned. Further reports of swarms in the Beersheba District are being investigated."

" 25.iv.28. Swarms were reported on the 24th instant from Turmos Aya in the Ramallah district, from Khan Ahmar on the Jerusalem-Jericho Road, and from the Mount of Olives. On investigation these were found to consist of a few scattered locusts which were dealt with by village labour. Gaza, Khan Yunis and Beersheba were reported to be practically clear of locusts on the evening of 24th instant."

" 26.iv.28. A very dense swarm of locusts covering an area of 700 dunams (approx. 155 acres) was destroyed by the Jericho Field Company with flame-guns near the Dead Sea Post on the night of the 25th–26th instant. A fresh swarm has been located at Auja, to the north of Jericho, against which action is to be taken this evening."

" 27.iv.28. A strong westerly wind drove the remnant of the swarm partially destroyed near the Dead Sea Post on the night of 25th–26th instant back across the Jordan to El Metull at the north-west angle of the Sea. A report of a large swarm in the Wadi Farah east of Nablus is under investigation. Small swarms were reported on 26th instant at several points along the northern border in the Huleh, Safad and

Acre Districts. Such swarms probably represent the rearguard of the main swarm which passed into the Lebanon on 22nd instant and are being destroyed by village labour."

" 28.iv.28. A large swarm of flying locusts has been located at Athlit. The Haifa Field Company has been despatched to the area with flame-guns. The Nazareth Field Company is dealing with a second swarm near Sukhnin in the Acre District. The remnants of swarms destroyed in the neighbourhood of Jericho are now reported to be laying. Egg-patches are being defined and will be ploughed up."

" 29.iv.28. Swarms at Sukhnin in the Acre District and at Rummane north of Nazareth were destroyed during the night of 28th–29th instant with flame-guns. An egg-patch of 200 dunams (approximately 45 acres) has been defined at Rummane in very hard ground. Poison will consequently be employed for the destruction of hoppers on hatching. The swarm earlier reported as coupling in the Shuneh Valley crossed the Jordan to an area west of Jericho where it is now laying. Egg-patches are being defined and will be ploughed up."

" 8.v.28. Another large swarm of flying locusts crossed from Transjordan into Palestine near Jisr Majamieh on 7th and was in movement westerly through the Esdraelon from Beisan to Haifa with a lateral extension from Nazareth to Hawarah near Nablus, on the morning of the 8th instant. Smaller scattered swarms passed westerly over Jerusalem and Hebron at the same time."

" 9.v.28. A large part of the swarm reported as having passed westerly up the Esdraelon on the 9th instant settled densely in the evening in the pass between Megiddo (Abu Shusheh) and the Nazareth Hill. Outlying swarms were located at Zicron Jacob and Balfouria near Afulleh. Four field companies from the Haifa group and a detachment from Jerusalem with 45 flame-guns destroyed the bulk of all these swarms during the night. As the locusts are now coupling and not likely to move, it should be possible to complete destruction to-night. A large swarm was in movement over Tulkarem on the 8th instant and will probably settle on the coastal sand-dunes which are being patrolled from Jaffa and Haifa. Scattered swarms were reported during the same day on a line Hebron-Artuf-Bab-El-Wad. Action will be taken as soon as the swarms settle."

" 10.v.28. Destruction of extensive swarms at Megiddo, Nahalal and Afuleh in the northern plain, and at Ain-El-Ghazal near Zicron continues. Two new swarms were located during the afternoon of the 9th instant at Karuba near Jenin, one of which was destroyed during the night by the Nablus Field Company. Other swarms settled at Beisan and Sehfr Amr on the morning of the 10th instant. Twenty additional flame-guns have been transferred from Jaffa and seventy units are now available in this area. As egg-laying is imminent, little further movement of swarms is likely and their destruction is only a matter of time. Damage has been negligible. Scattered swarms are still in movement over the Jerusalem and Hebron Districts. Owing to the drought and consequent hardness of the soil, locusts are apparently having difficulty in finding suitable ground for egg-laying. It is anticipated that in such circumstances irrigated groves and the coastal sand-dunes will be selected. Some egg-laying has already been reported from Gaza."

" 11.v.28. Extermination of the flying swarm in the northern plain was practically completed during the night of 10th–11th instant. Locusts commenced to hatch out at Jericho on 10th instant, and the campaign consequently enters on a second stage. Trenching material has been assembled for immediate use at Jericho and in the Shuneh Valley as soon as lines of movement have been determined."

" 20.v.28. Further swarms of flying locusts entered Palestine from the east on 13th and 14th instant and settled at Abu Shusheh north of Tiberias, at Batuf north of Nazareth, and on the lands of the Arab S'beih near Mount Tabor. At the two

former centres, areas of approximately one thousand dunams (approx. 222 acres) were covered, while the third swarm was somewhat smaller. As the locusts were gravid and showed little tendency to further flight, it was found possible to encircle the swarms after dark and drive the insects to central points where they were destroyed in dense masses by the flame-guns with a minimum expenditure of fuel. The erection of portable 'Lux' lamps in the centre of the swarm, both attracts the locusts and facilitates driving operations. Destruction of all these comparatively large swarms was completed within four nights and the country was reported to be practically clear of flying locusts on 19th instant. Young locusts have now emerged in the Jericho District and in the Shuneh Valley across the Jordan. Additional labour has been sent to both areas to expedite the wheat harvest. The wheat is being cut high and the long stubble will be burnt as soon as the grain has been harvested. In the meantime young locusts in the open are being destroyed with a kerosene soap emulsion spray. This is the most effective method of controlling young locusts in the earliest stages of development and before definite lines of movement are established. Poisoning and trenching are indicated for 'hoppers' in a more advanced state."

"22.v.28. The country is apparently clear of flying swarms. It is reported that over one thousand volunteers assisted in driving operations at Abu Shuneh, Batouf and Arab S'beih on the night of 18th instant. Nearly all the wheat in the Jericho area has now been harvested with the assistance of labour sent from Ramallah, and stubble-burning is proceeding wherever young locusts are in evidence. Flame-guns and the paraffin-emulsion spray are being applied where a satisfactory 'burn' cannot be obtained. Trenching operations in protection of the Jericho plantations have been organised."

"31.v.28. Destruction of small swarms of 'hoppers' is proceeding satisfactorily. The Northern district is reported to be practically clear and the situation is well in hand at Jericho. Negligible damage has been done. The Jordan Valley has been patrolled on both banks from the Dead Sea to Jisr Damieh and is reported free from locusts except near Jericho."

In conclusion, it may be stated that practically all the hoppers that emerged at Jericho were exterminated, as well as a few, small, isolated patches that occurred in Northern Palestine. It will be observed that in the main there were three successive waves of invasion, coming either from the south, south-west or the east. By comparison with the event of 1915, it was but a light invasion but of sufficient severity to have caused considerable damage if control measures had not been put in force with promptness and energy. The locusts arrived in their major quantities at a much later date than in 1915. This year the late rains failed completely, and hot, dry weather set in at a very much earlier date than is usual in the Palestine climate, with the result that these insects found very few suitable places in which to lay their eggs—a fact which seemed to worry them and cause their restless flights from one place to another. These two factors—their late arrival and an unusually rapid and early drying up of soil conditions—proved to be very helpful. Egg-laying in Jericho was confined to irrigated land, and it was only here that the hoppers gave any serious trouble. It would seem that an early arrival of the swarms commencing half-way through March, combined with the incidence of a late season and a simultaneous attainment, on arrival, by the locusts of a state of sexual maturity are vital factors for a successful locust invasion—successful, that is, from the point of view of the insect. How often such events coincide is unknown, as apparently no reliable scientific observer has recorded such information, in Palestine, prior to 1915.

**Organisation of Campaign and Control Measures Utilised.**

A vital factor of success in dealing with a locust invasion is the ability, if circumstances permit, to anticipate such an event. It was possible to do this in the 1928

invasion of Palestine. The appearance of the Nejdian locust (*Schistocerca gregaria*, Forsk.) in the Hauran during 1927, search for an eventual access, during October 1917, to literature concerning past invasions and their dates, and the appearance during November 1927 of migratory locusts of the same species in Egypt, enabled the Entomological Section of the Department of Agriculture to predict with accuracy that 1928 would be a locust year.

Another vital factor in dealing with a locust invasion is preparedness—the purchase in good time of adequate supplies and equipment, the introduction of comprehensive legislative measures, training of personnel, and widespread propaganda among the population of the country. Work on such measures was commenced by the Entomological Section in December 1927, and completed by the end of February 1928.

With regard to supplies and equipment, the purchase and distribution were dealt with in two parts, so as to ensure as much economy as possible, and I may quote here from my written proposals which were adopted by the Government of Palestine :—

> " Purchase of material and equipment in readiness for a locust campagin, as far as this country is concerned, falls into two periods :—
>
> " (*a*) Purchase of material and equipment which will be required immediately for action against the swarms of winged locusts on their arrival. It is essential, therefore, that such things be purchased, prepared and distributed before the advent of these insects so that control measures may at once be put in hand.
>
> " (*b*) Purchase of material and equipment as soon as the arrival of the swarms takes place, which items will not be required till the eggs hatch and hoppers appear. A period of not less than four weeks must elapse between the arrival of winged forms and the hatching of the eggs which they deposit; this gives adequate time for purchase, preparation and distribution.
>
> " In the case of the locusts not appearing, if the above plan is adopted, a considerable financial saving will be effected as the purchase referred to in (*b*) will not be made. It should be pointed out that if the locusts do not arrive many of the things purchased and referred to in (*a*) can be readily utilised for entomological purposes other than locust control ; other items will not deteriorate by the passage of time and will be ready for future invasions which, as records of the past indicate, occur every 12 years."

With regard to these two categories every possible and practical method of locust destruction was exploited and only those adopted which a study of local conditions made by the Entomological Section during the past six years indicated to be most practical. My personal and modern experience in another locust campaign[7] was also brought to bear. Under category (*a*) 150 flame-projectors were purchased and distributed. The flame-projecting part of this apparatus, which is described later in this paper, was evolved by the Entomological Section after much experimenting. These machines were, of course, not intended to form a complete panacea against this pest but as a special instrument to assist in dealing with the winged forms under the most favourable conditions. Certain accessories for the use of this equipment were also provided, such as large metal tanks of a convenient size, shape and portability, in which the fuel for the flame-throwers could be mixed and kept to facilitate charging, and an adequate supply of fuel at three main points throughout the country. Special spanners and spare parts were likewise supplied.

Two thousand hand nets were constructed and distributed ; cheapness combined with strength were studied and a very serviceable article was produced for collecting winged locusts by hand during the early morning hours.

With regard to poison, two tons of sodium arsenite, one ton of Paris Green and two tons of molasses were held in stock, and arrangements made whereby large stocks of these poisons could be obtained within a few days' notice. From a part of this stock 180 drums of locust poison (*i.e.*, a mixture of molasses and sodium arsenite for preparing poisoned bait or for spraying directly on vegetation) were made up and distributed. This quantity of drums represented 18,000 gallons of poison ready for use. Further supplies could have been made up at a few days' notice.

Under category (*b*) zinc sheeting for trapping young locusts ('hoppers') was purchased. The total quantity of this sheeting when erected continuously, and the requisite number of pits for trapping the hoppers dug in front of it and lined with sheeting, would have stretched over some nine miles of land. Preparations were made so that a further, almost unlimited supply could have been obtained within a very short period. Arrangements for an adequate supply of tools for erecting such sheeting were made.

The legislative measures taken were comprehensive. The Plant Protection Ordinance of Palestine very clearly lays down the duties of cultivators in the event of a locust invasion, and heavy fines or imprisonment await those who fail to carry out the Orders thereunder. Certain powers also exist under the Ottoman Law. Duties which would be exacted from the rural population and all heads of villages or communities and the penalities for non-compliance were circulated all over the country. At the same time the system of rewards for notification of arrival of winged swarms, deposition of eggs and emergence of the hoppers was similarly circulated.

It is of interest to note that no payment for egg collection was contemplated; the good-will of the population stimulated by the existence of enforced control by law were deemed—and indeed proved—to be sufficient.

Training of personnel was carried out by means of lectures and practical demonstrations to all personnel of the Department of Agriculture given by myself with the assistance of my staff over a period of some two months. By means of photographs, drawings and special instructions, every effort was made clearly and vividly to impress the technique of flame-throwers, erection of zinc sheeting and digging of pits, mixing of poison, organisation of labour, life-history and habits of the locusts, etc. Departmental personnel were divided up into Field Companies and allotments of transport were made. The duties of such companies were to supervise the more technical means of control such as trenching, poisoning and handling flame-projectors. Other non-technical matters, such as organisation of labour and implements for ploughing, were delegated to members of the Police and Administrative Departments.

Propaganda to the general public consisted in a course of lectures and practical demonstrations which covered every phase of the proposed campaign. These were given by myself, assisted by the staff of the Entomological Section, at seventeen centres all over Palestine, and were attended by some two thousand people.

Previous mention has been made of the difficulty of obtaining accurate information of the 1915 locust episode and the efforts made to gather information from inhabitants who were in Palestine during that year. In pursuance of this policy I was informed by the Mayor of Ramleh that in 1915, in the Jaffa area, the majority of egg-laying took place there on the large sand dune area and its vicinity, and it was owing to the impossibility of organizing a sufficiency of labour for egg destruction in this practically uninhabited stretch of country that the greater part of these eggs hatched and the resultant hoppers eventually marched on the orange cultivations of Jaffa and demolished them. Further inquiries elicited the information that the same thing occurred all along the coastal area wherever sand dunes existed. Acting on this information and in order to deal with a possible recrudescence of this event during 1928, patrols were organized by the District Administration of Northern and Southern Palestine which, as soon as winged locusts were first reported at Jericho, covered the

whole of this dune area and were under definite instructions at once to report arrival of swarms and to mark egg-laying patches. An organisation was ready whereby almost unlimited quantities of labour could be brought to such places for the work of egg-destruction. Patrols were similarly instituted in the sandy districts of Beersheba and Gaza.

## The Campaign.

This year was the first time that the locusts, on their periodical invasion of Palestine, were met with an organisation of material, equipment and personnel. Their reception was, literally, a hot one.

Under the Ottoman régime, during the 1915 invasion, Government control measures consisted in paying one bishlick (15 mils=4d.) per rotol (slightly more than six pounds) for the winged locusts and, later, a decree that every male person must collect 18 kilograms (about 40 lb.) of eggs and all proprietors must plough up their arable land. Owing to a number of circumstances—principally to non-enforcement of such measures in a number of districts—the locusts got the upper hand. In Jerusalem the eggs collected were placed in a large store and, if a number of very reliable witnesses are to be believed, as soon as this store was in receipt of a fair number of eggs, it was possible to apply at the *back* entrance and there *purchase* from the engaging individual in charge the correct amount of eggs decreed for collection by each male member of the population. A visit, later, to the *front* door for delivery of these eggs would then be made and a receipt obtained to the effect that one's duty by the Government—so far as the collection of locust eggs was concerned—had been fulfilled. Thus all parties were satisfied—particularly the storekeeper. Many parcels of eggs must have embarked, and continued, on a passage from back door to front door and back again to the rear entrance of the store. This store gradually got filled, however, as many impecunious people were forced to go out and collect the requisite number of eggs. The eggs in the store eventually hatched and the unpleasing spectacle was presented of all available exits thereform literally vomiting young locusts in millions and millions.

From past experience and evidence collected in Palestine it was obvious that the destruction of as many winged locusts as possible, prior to egg-laying, would prove to be an undertaking very well worth while. Every female locust killed, prior to egg-laying, represents the destruction of some hundreds of prospective young locusts. Poison is out of the question, as such swarms, on their arrival in this country, eat very little and are more concerned with their domestic affairs. There exist, also, large tracts of land with but very few inhabitants, and the organization of adequate labour there is consequently difficult. To deal with this set of circumstances the previously mentioned form of adaptor fitted to an ordinary compressed-air spraying machine, so that it could be utilised as a flame-thrower was devised, and after much experimenting a cheap and efficient fuel was discovered. These machines complied with the necessary requirements of portability, no complication in use, comparative cheapness, efficiency, and, provided ordinary precautions against the handling of inflammables were observed, safety. Advantage was taken of the habit of this particular species of locust of clustering in dense masses during the night—a habit particularly marked at temperatures ranging downwards from 65° F. The colder the night and early morning hours, the less inclined these insects become to move, and in such circumstances the flame-projectors can, and did inflict immense destruction, which very handsomely repaid expenditure on fuel and other items.

Such work was accomplished without scattering of the individuals composing a swarm and thus giving rise to indiscriminate egg-laying over a wide area. It was soon observed, however, that as the period of oviposition drew near the swarms

evidenced a strong disinclination to leave an area where they had apparently decided to lay their eggs, and in such circumstances it was possible, night after night, to proceed with the work of destruction. Prior to this, as the reports issued by this Department indicate, it was a question of following up late afternoon reports of swarms having settled for the night and killing as many individuals as possible before it moved off at 8 a.m. the following morning. Current means of communication in Palestine, such as a very adequate telephone system, distribution of District Administration and Police Department personnel, and good motor transport, as well as many good roads and tracks, made such action possible.

In many instances large numbers of villagers were turned out to assist in the work of destruction. They were armed with the hand nets previously described and further assisted, in some areas, by encircling the swarms of gravid locusts and slowly driving them to a common centre to be exterminated by means of the flame-guns.

So efficiently was this method prosecuted that egg-laying was confined to a number of small areas, in irrigated land, about the town of Jericho. As mentioned in the foregoing reports, egg-laying commenced in Jericho on 27.iv.28, and continued intermittently over a period of several weeks, hatching of these eggs likewise continued over some weeks, the period between oviposition and emergence being 15–16 days. The process was hastened by the extreme heat in this part of Palestine. In other parts where the climate is much cooler, the eggs took slightly over a month to hatch.

Egg-laying took place in the Jericho area principally in irrigated land, such as cornfields and banana cultivations, but never densely or in closely confined areas. In this part of Palestine the visiting winged swarms scattered to an extraordinary extent and their elimination proved difficult. Matters were complicated by heat waves of almost unendurable temperatures (Jericho is 1,100 feet below sea-level and a shade temperature of 47° C. (116·3° F.) was experienced during this period), and the consequent difficulty of maintaining personnel in such circumstances. The hoppers were easily destroyed by spraying with kerosene emulsion in their earliest stages and later by fire and poison. Their numbers were insufficient to form large "armies".

Mention has been previously made in this paper of the purchase of large quantities of zinc sheeting for use against the hoppers. Owing to the fortunate shortage of these insects it was not necessary to use this material, but a brief description here of the methods it was proposed to employ will not be out of place.

The principle is to arrest the progress of large swarms of hoppers by means of a wall of zinc sheeting erected across their line of march and in front of this sheeting to dig pits into which the locusts fall and are unable to emerge owing to the edges of the pit being lined with zinc sheeting laid flat on the ground so that the edge projects over the edge of the pit. The brightness of the sheeting at the pits is obscured by covering with a thin layer of soil (Plate IX, fig. 2).

Hoppers when moving in armies proceed in two different ways: either in column formation, the column being possibly several kilometres in length with a front of some 100 to 200 metres, or the advance is made on a wide front of, say, one kilometre with a depth of half a kilometre. In this second method of advance the insects are never anything like so densely packed as when moving in column. The wide front indicates that the hoppers are feeding as they advance ; the column, that they are moving in search of food.

To deal with the column formation a trench is dug some 100 centimetres wide, 100 centimetres deep and of a sufficient length to cover adequately the front of the on-coming swarm ; above the back wall of this trench a line of zinc sheeting is erected. At each end of the trench labourers are posted holding strips of white material so as to form a wall which extends outwards at an angle from the end of the trench. The

object of these cloths is to frighten the hoppers and to force them to march straight ahead into the trench. The edges of the pit are lined with zinc sheeting as described above.

As soon as the trench is full of hoppers, earth is thrown on them and the whole trampled down; while this trench is filling, a further, similar trench and wall are being erected some 12 metres behind the first, so that as soon as the latter is full, the sheeting is pulled up and the hoppers allowed to continue their march on to the second trench.

The work goes on all day, and 100 labourers, properly equipped, can dig 50 such trenches during the course of twelve hours.

This method is, of course, only applicable to land where not many rocks exist. I am indebted to Mr. C. Weizman, late of the Agricultural Department, who very kindly placed at my disposal his experiences gained in the 1915 invasion.

The zinc sheets referred to throughout this paper are uniform in size and weight; they are cut from sheets known to the trade as No. 11 and are 2 by 1 metres in size. From each of these large sheets are cut three strips, each strip being 2 metres in length and 33⅓ cms. in height. They are held upright in position in the field by means of iron pegs (Plate IX, fig. 2).

To deal with hoppers moving on a wide front of one kilometre, an adequate length of sheeting is erected and pits dug in front thereof at varying distances, such distances being governed by the size of the swarm it is proposed to combat. The sheeting is erected some 20 yards in front of the swarm, work being commenced late in the afternoon when the hoppers cease to move and are preparing for the night when they are immobile. Work is recommenced very early the following morning as everything has to be ready by the time the swarm commences to move.

As soon as the young crawling locusts meet the zinc wall, they start to move along the base looking for a way through and sooner or later encounter the place where the zinc is curved outwards to the edge of a pit. Being unable to crawl further and being urged from behind by other hoppers they fall into the pit. Some hoppers may fall into the pits before reaching the wall. No driving of the swarm is necessary or expedient; they advance quite naturally and are trapped. It is, of course, an easy matter to destroy the hoppers once they are in the pits and unable to emerge. This method has the added advantage that if it is found impossible to exterminate the whole swarm owing to underestimation of its size the sheeting may quite simply be removed and re-erected later when the swarm has collected together again as it surely will. It is best executed on plains or slightly undulating land where the rock is not too near to the surface.

I am indebted to the very excellent and very complete account[2] of the locust campaign in Syria during the war period for the principles of the above method; also to Mr. P. Jolles, of the Entomological Section, who rendered valuable assistance in co-ordinating such principles to suit local conditions.

It became obvious to me from my experience in the locust campaigns in Palestine and Transjordan this year that ploughing up the land so as to expose the egg-masses of the locusts to the sun and air for destruction has to be very efficiently performed to ensure complete success. When using the native plough, it must be worked to its full depth, and cross-ploughing should be practised. The European plough is, of course, infinitely preferable for such work, but in Palestine it is rarely available. It is doubtful if ploughing could be performed on the sandy land referred to earlier in this paper, which would indicate the need of a very large labour supply for hand methods.

## Locusts as Food.

The well known Biblical quotation of a diet of " locusts and wild honey," so far as locusts are concerned, still holds good. The inhabitants and Beduin tribes of the Jordan Valley greatly appreciated the arrival of the winged swarms this year, and it was no uncommon spectable to see numbers of these people returning from the early morning campaign laden with sacks of locusts which they kept with them in their houses, each day drying a small number in the sun, afterwards frying them in oil and consuming them. In Transjordan the locusts fetched a fair price for food.

The avian and mammalian fauna of Palestine enjoyed a rich diet in places where the winged swarms appeared. Birds such as sparrows, bee-eaters, and especially storks, assisted the efforts of the Government and population in the work of destruction.

## The Locust Invasion in Adjoining Territories.

Egypt, Transjordan and Syria, all experienced locust invasions of the same species this year. From local reports it appears that both Syria and Transjordan were far more heavily infested than Palestine. I personally inspected a very large swarm of winged locusts closely covering some six hundred dunams (1,300 acres approximately) in Transjordan. Other, equally large, swarms were moving about in the same territory for several months. Control methods in that country were based on the methods adopted in Palestine and were executed by officials who had previously been given opportunity of studying supplies and technique evolved in Palestine. The results were entirely successful, for by diligent destruction of winged swarms with flame-projectors and hand nets and by the energetic ploughing up of egg-laying areas, the campaign against the hoppers that eventually emerged was neither prolonged nor exacting.

## Experienced Gained.

An accurate prediction of a locust year and the existence of an organisation having at its back a plentiful supply of materials and equipment, the good will and confidence of the population and adequate legislative measures, are *sine qua non* for the successful prosecution of a locust campaign.

As civilisation progresses, the very important rôle assumed by insects in human affairs is becoming to be better understood and appreciated. Our knowledge, however, of the origin of these periodic invasions of Palestine is practically nil. It is clearly indicated that for some years prior to a locust year the movements of locusts in Arabia, Eritrea, Sudan, Egypt, Abyssinia, Yemen and the Hejaz should be studied by competent observers, so that the size of the coming invasion could be estimated broadly. The encouragement of anti-locust measures in the less enlightened of these areas should certainly be fostered. Prevention, after all, is superior to cure ; it is certainly cheaper in the end. Only by attacking the locusts in their original breeding grounds can these eminently costly and demoralizing, periodic invasions of the Holy Land be limited or happily averted.

The activities of the recently formed International Locust Bureau of Damascus should receive the support and financial assistance of all countries in the neighbourhood of Syria, and efforts should be made to execute the programme of observation and intelligence as outlined above.

*Note on a Flame-Projecting Apparatus for Use against Locusts.*

## Introductory.

Some months prior to the author's appointment to this country in 1922, a battery of six Hay Flame Guns, complete in every detail, was purchased by the Palestine Government for use against locusts. After exhaustive trials with these instruments over a period of several years, the present writer concluded that this particular machine, although an effective weapon in human warfare, was of little use in fighting locusts, where cheapness, portability and simplicity are factors of prime importance. It is not proposed to enter into details here as to why the Hay Flame Gun was found to be wanting in these particular requirements.

In the early months of 1927 the writer's attention was drawn by one of his assistants to a publication[2] of German origin concerning the methods of control devised for use against locusts in Syria during the war period. This book, which is probably one of the most exhaustive works on locust control under local conditions in existence and admirable from every point of view, contained an account of a flame-projecting apparatus which could be fitted to an ordinary hand-operated knapsack spraying machine. The idea occurred to the writer to fit a greatly improved form of this contrivance to an efficient type of compressed air spraying machine that had been previously purchased for spraying operations against various insect pests in this country. After a large number of experiments with various forms of flame-adaptors the type described in this paper was evolved and has been found to give efficient and valuable service during the anti-locust campaign of 1928. The author must here acknowlege the contribution of valuable ideas and assistance in this work from his Senior Field Assistant, Mr. B. S. Farajallah, and from his Laboratory Assistant, Mr. P. Jolles.

## Description of Apparatus.

A general view of the complete machine is shown in Plate VII. As previously stated a compressed air spraying machine of standard make is used, and to it is fitted the special adaptor for flame-projection. Any form of good compressed air spraying equipment can be utilised for this purpose. After extended use, however, the author has found the "Weeford Pattern," as manufactured by the Four Oaks Spraying Machine Co. of Sutton Coldfield, Birmingham, England, to give excellent service; it is strongly made, withstands hard work, and is portable, and the combination of filling and charging with air at one operation is very useful, as it allows a large number of machines to be charged from one central tank at the same time.

In place of the twin spraying nozzles, which are screwed normally to the end of the spraying lance, is inserted the cone adaptor for flame-projecting purposes. The exact mechanical features of this apparatus are clearly indicated in the two accompanying photographs (figs. 2 & 3) of actual scale drawings thereof; in Plate VIII, fig. 1, which shows the component parts of the adaptor, including the spraying lance with tap, which has been detached from the spraying machines for purpose of illustration; and in Plate VIII, fig. 2, which demonstrates the appearance of the adaptor when assembled.

In assembling the apparatus the copper cone (3 in scale drawing) is first of all slipped on the brass rod (1 in scale drawing) with its narrowest end (4 in scale drawing) in proximity to the thickened end of the rod. The metal "basket" (2 in scale drawing) which carries the asbestos is then fitted so that the ring bearing the milled screw slips down the tube into the narrow end of the cone. Finally the jet (5 in scale drawing) is screwed on and well tightened up. The rod, jet, milled screws, and the ring of the "basket" which slips on the rod are all of brass. The cone and

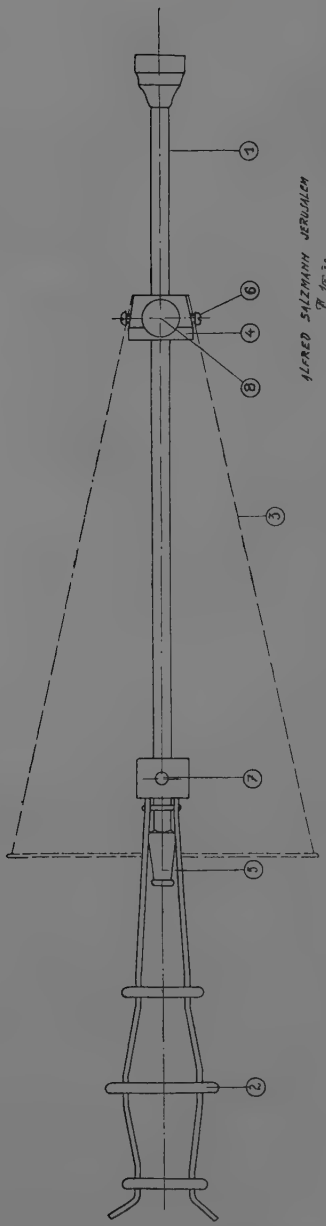



Fig. 2. Scale drawing of mechanical features of cone adaptor for flame-projecting apparatus.

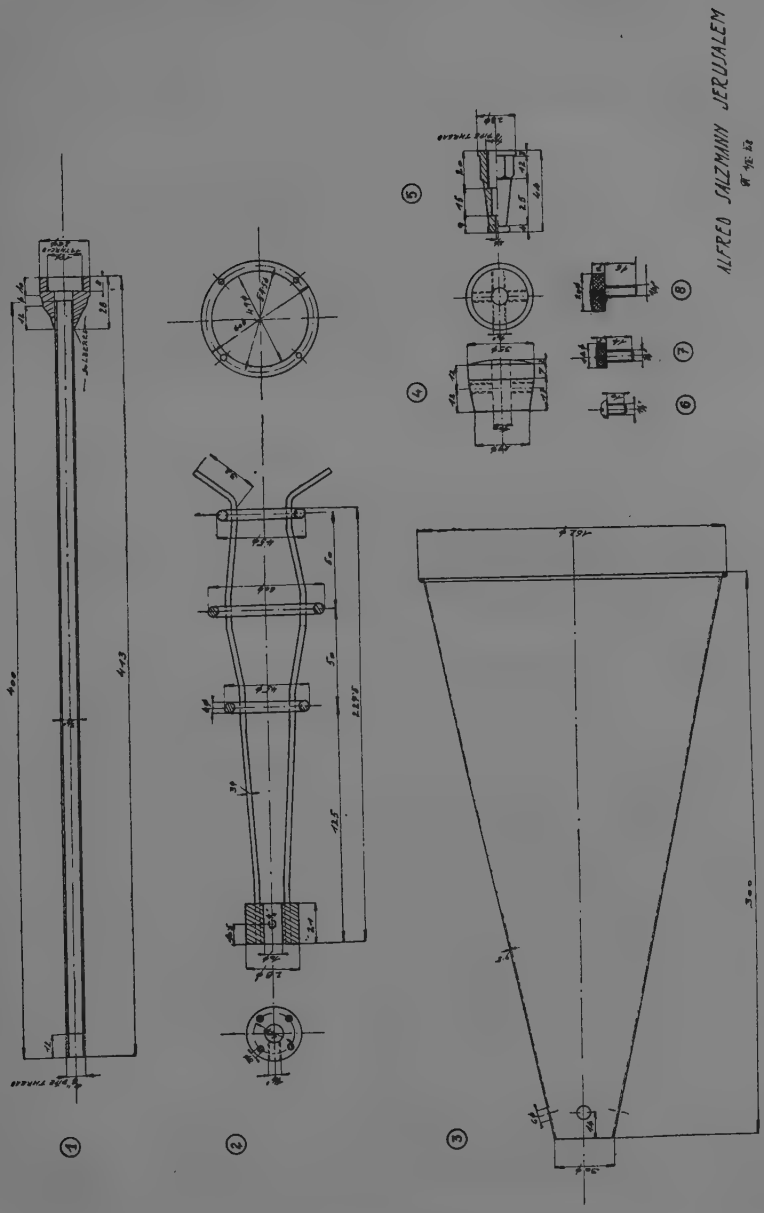



Fig. 3. Scale drawing of mechanical features of cone adaptor for flame-projecting apparatus.

those parts of the " basket " which fit into its brass ring bearing the milled screw are of copper. In use the ring of the " basket " is pushed up the rod till it is in close contact with the base of the jet and held there, in position, by means of the milled screw. The copper cone is then also pushed up the tube till its narrow end is in close contact with the brass ring of the " basket " ; it is held firmly in this position by means of the milled nut at its base. Thus the cone adaptor is adjusted and made ready for use.

The copper " basket " as shown in the scale drawing has, after manufacture, to be lapped with asbestos string. Lapping is commenced at the lowest copper ring and continued till the third and top ring is reached ; the projecting ends of the copper wire, as shown in the scale drawing, are then bent down on to the asbestos and serve to keep it in position; Plate VIII, fig. 2, portrays the appearance of the " basket " after having been lapped with the asbestos. It will thus be seen that the asbestos string is readily renewable, and all parts of the apparatus are easily taken apart for cleaning, repairing or adjusting. A large number of the adaptors have been made by the engineering firm of Messrs. Salzman, Jerusalem, Palestine, to our specification at the rate of 800 mils each (16s.). The spraying machine fitted with the adaptor weighs, uncharged, 21½ lb.

## Method of using the Machine.

The compressed air spraying machine is first charged with the requisite quantity of two gallons of fuel. This is accomplished automatically in this particular type of sprayer by means of first raising the pressure to 15 lb. per square inch, connecting up the intake hose with the tank holding the fuel previously prepared and then raising the pressure to 50 lb. per square inch. The intake hose is then disconnected and the apparatus is ready charged.

To prepare the cone adaptor for use, the copper cone is pushed back as shown in Plate VIII, fig. 2, and the asbestos soaked with the fuel with which the machine is charged. It is then ignited and the cone pushed back into position. In a few seconds, as soon as the cone has become well heated, work may be commenced. On opening the taps, the fuel, on being forced out under pressure through the nozzle, has to pass through the basket holding the burning asbestos and there becomes ignited, issuing finally as a stream of fire some 15 feet in length. After many tests with a great variety of fuels a form of cheap Diesel oil mixed with petrol, in the proportion of two parts oil to one part of petrol, was finally adopted. In using these machines in the field ordinary common-sense precautions against fire must necessarily be observed. Care should be exercised in seeing that all parts are well screwed up and that the leather washers are properly inserted so as to prevent any leakage of the fuel on to the operator's clothing. Plate IX, fig. 1, shows one of these machines in action. The operator is confronted with a mass of winged locusts clustering on low-growing vegetation on to which he is playing the fire. Destruction, under favourable circumstances, is 100 per cent. A patent is pending for this apparatus.

## Cost of Utilising Flame-Guns.

These machines were devised, and used, as an added method of destruction of migratory swarms of winged locusts during the night and early morning hours when they are torpid.

The experience in this country has been that such swarms eat little or nothing; consequently poison methods are out of the question. It must be borne in mind, when

considering the cost of using these weapons, that if it is possible to destroy such swarms prior to egg-laying, further expenditures on egg destruction and extermination of hoppers will not be necessary.

At local prices of fuel oil and petrol, and taking into consideration transport and labour charges, it costs 50 mils (1s.) to fire a charge from one of these machines. The charge will burn for ten minutes continuously; in practice, however, this is seldom done, as short bursts of fire are usually indulged in, and machines, on the average, return every 20–25 minutes for recharging.

In the Jericho area of the Jordan Valley, during the campaign, fifteen flame-guns eliminated during one night a dense swarm of winged locusts which had settled on uncultivated vegetation over 700 dunams of land (155 acres).

It has been proved by field experience that where winged locusts are congregated thickly on low uncultivated bushes or on the ground there is no more economical or efficient method of destroying them in a comparatively short space of time than by the use of flame-throwers.

*References.*

(1) The Holy Bible. Exodus, Chapter X.

(2) Bücher, H. Die Heuschreckenplage und ihre Bekämpfung. Monog. angew. Ent., iii, 274 pp., 33 figs., 20 pls., 11 maps. Berlin, 1918.

(3) Aaronsohn, A. La Lutte contre le Criquet pelèrin.—Bull. no. 2 Station agronomique juive, près Haifa. Jerusalem, April 1915.

(4) Rosenberg, L. Die Heuschrecken in Palestina.—Tropenpflanzer, xviii, pp. 657–669, 3 figs. Berlin, 1915.

(5) Report on the great invasion of locusts in Egypt in 1915.—Ministry of Agriculture, Egypt, Government Press, 72 pp., 14 pls., 2 diagrs. Cairo, 1916.

(6) Rokach, S. A report on the locust invasion of Palestine of 1915.—The Palestine Citrograph, iv, p. 14, May 1928.

(7) Bodkin, G. E. An invasion of British Guiana by locusts in 1917.—Bull. Ent. Res. ix, pt. 4, pp. 341–348. London, July 1919.

The flame-projector complete.

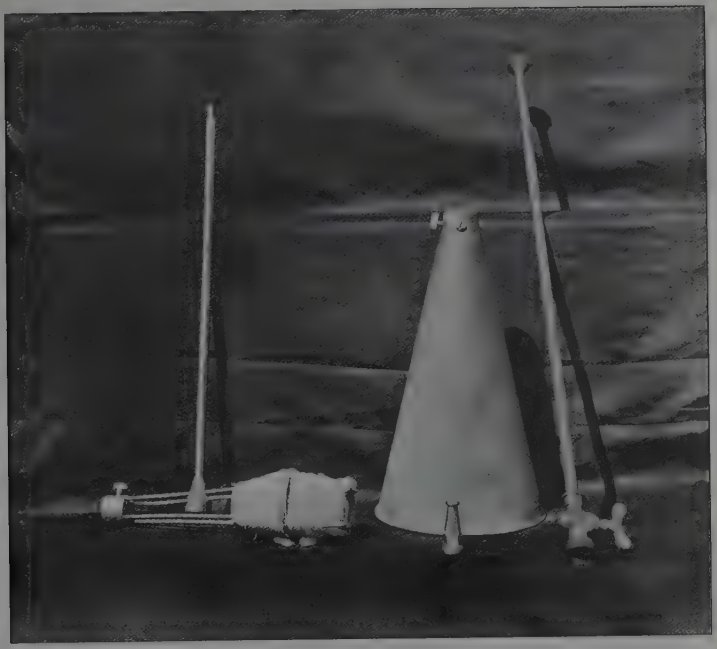


Fig. 1. Component parts of cone adaptor for flame-projecting apparatus.

Fig. 2. Appearance of cone adaptor when assembled for use.

Fig. 1. The flame-projecting apparatus in action against locusts.

Fig. 2. Zinc sheeting erected to trap hoppers advancing on a wide front.

# MULTIPLE PARASITISM: ITS RELATION TO THE BIOLOGICAL CONTROL OF INSECT PESTS.

By HARRY S. SMITH,

*Citrus Experiment Station, University of California, Riverside, California, U.S.A.*

*" The condor lays a couple of eggs and the ostrich a score, and yet in the same country the condor may be the more numerous of the two ; the Fulmar petrel lays but one egg, yet it is believed to be the most numerous bird in the world. One fly deposits hundreds of eggs, and another, like the hippobosca, a single one ; but this difference does not determine how many individuals of the two species can be supported in a district."*—Charles Darwin, The Origin of Species.

The term " multiple parasitism " has been suggested by the writer* to designate that type of parasitism in which the same individual host insect is inhabited simultaneously by the young of *two* or *more different species* of primary parasites. As is well known, this phenomenon is of extremely common occurrence in nature. It appears to be almost a rule that the mother parasite does not distinguish between a parasitised and an unparasitised host and it often results, therefore, that she deposits her eggs in an individual that already bears a parasite egg or larva. If this other parasite happens to be of the same species, *super-parasitism* results. If, however, it is a different species, this phenomenon is known as *multiple parasitism*. In the case of solitary parasites such competition between two species attacking the same individual host generally results in the death of one or the other parasite. Often because of specific fitness one species is always dominant when two meet in competition.

Now in the practical work of introducing entomophagous insects into new habitats to aid in the control of insect pests, one is often confronted with this condition. Should it be taken into consideration in the selection of parasites for introduction? Are two species of primary parasites, competing with each other in this way, less effective than one alone would be or can such competition safely be ignored from an economic standpoint? There seems to be a conflict of views on this question among entomologists, and while it is a matter of great complexity when everything is taken into consideration, it is essential that its significance be understood.

If, as maintained by some entomologists, such competition results in a lower mortality of the host insect than would occur if only a single species were present, a grave error has been and is being made in most of the large biological control projects undertaken during the last fifty years. One frequently encounters statements by entomologists to the effect that it is a serious mistake to introduce two species which compete. It has even got into our text-books.

The biological implications of multiple parasitism were first pointed out, it is believed, by Dr. L. O. Howard in his excellent study of the parasitism of the tussock moth.† In this paper he states that " many parasites suffer from this rivalry based upon erroneous instinct." He did not, however, undertake to determine the effect of this competition on the group efficiency of the parasites.

Several years later Fiske§ called attention to this question, although in his discussion of the subject he did not clearly distinguish between what the writer prefers to call " superparasitism " and " multiple parasitism," which from an economic viewpoint are entirely distinct phenomena.

---

* Jour. Econ. Ent. ix, p. 486, 1916.

† Bull. 5, Tech. Ser., Bur. Ent., U.S. Dept. Agric.

§ Jour. Econ. Ent. iii, pp. 88–97, 1910.

It was largely on the basis of Fiske's recognition of the effects of this competition, within an individual host, between parasites of the same or of different species, that he evolved his so-called " sequence " theory, his idea being that this overlapping was so destructive to the parasites themselves that they could not reach controlling numbers when limited to a single stage of the host, but that this factor could be counteracted by the introduction of parasites attacking each of the several stages. This phase of the question is, however, essentially different from the one under discussion and has been fully dealt with by Thompson* and therefore need not concern us here.

The idea that two parasites competing in the same individual host insect may actually result in less destruction of the host than one of them alone would have accomplished was first advanced, I believe, by Pemberton and Willard.† Their discussion deals with the interactions of several species of Hymenopterous parasites introduced into Hawaii by Silvestri for the control of the Mediterranean fruit-fly (*Ceratitis capitata*, Wied.), all attacking the same stage of the host. The authors conclude : " Sufficient evidence has been presented to prove the superiority of the parasite, *Opius humilis*, over the other introduced fruit-fly parasites in Hawaii and demonstrates the decided restraint operated over it by the unfailing cannibalistic activities of the larvae of *Diachasma tryoni* in particular and of the other parasites in part. Knowing the capacity of *O. humilis* for parasitising 80 to 90 per cent. of the larvae of the fruit-fly in favourable localities, such as the large Kona coffee belt on the Island of Hawaii, the writers here maintain that detrimental results to a certain extent have arisen from the liberation in Hawaii of parasites other than the *O. humilis* that attack the larva of the fruit-fly. The total parasitism has simply been reduced in value to that of a parasite of secondary value."

In other words *Opius humilis* acting alone, in the opinion of these authors, would have accomplished greater destruction of the host than the total destruction brought about by all the introduced parasites acting together on the larval stages of the host. This is a matter of immense practical significance, and if the authors are correct in this stand, it will be necessary to make radical and extensive changes in most biological control programmes.

Now several types of competition may occur between two parasites attacking the same individual host, and it may simplify the discussion if we define them and place them in separate categories. The behaviour of the parasites may differ in two ways ; first, in relation to each other, and second, in relation to their environment.

The two parasites may be equally fitted to survive the competition within the host, the issue being decided solely by the time of attack or by some other factor not characteristic of the parasites themselves ; or one species is especially fitted to survive because of certain specific qualifications, either superior mouth-parts, or greater aggressiveness, or because it secretes some toxic substance fatal to its rival, or for some other reason. In order to distinguish between the two we may call these types " intrinsically superior " and " intrinsically inferior " parasites.

In relation to their environment we may also group the parasites into categories. The tendency of parasites, as with all other organisms, is to maintain a constant population. Other things being equal, the parasite which maintains the higher average population will be the more efficient, and the population is largely determined by the environment. In order to make this more clear, we may make use of a term often employed by naturalists, the " ecological niche." These niches are determined by the combined effect of all environmental factors, both physical and biological.

* Ann. Ent. Soc. America, xvi, pp. 115–125, 1923.

† Inter-relations of Fruit-fly Parasites in Hawaii. Jour. Agric. Res., xii, pp. 285–295, 1918.

Every species has a certain average number of ecological niches which it can occupy. When all ecological niches available to a given species are occupied, that species is said to have reached its saturation point. This saturation point tends to fluctuate with each species, but, nevertheless, the average population in a given locality is rather definitely fixed, although it obviously has very different values for different species. As between two parasites, for example, one may have a higher saturation point than the other. We may designate these as " extrinsically superior " and " extrinsically inferior " parasites.

We may have then, in a case of multiple parasitism, the following conditions : one parasite may be either intrinsically superior, intrinsically inferior, or intrinsically equivalent, to the other. It may also be either extrinsically superior, inferior, or equivalent, to the other. There could occur, then, the following types of manifestations of multiple parasitism :

(1) Neither species is intrinsically or extrinsically superior.

(2) One species is intrinsically superior, but neither species has any extrinsic superiority.

(3) One species is extrinsically superior, but neither has any intrinsic superiority.

(4) One species is both extrinsically and intrinsically superior.

(5) One species is intrinsically superior but extrinsically inferior.

Now before attempting to analyse these various combinations of multiple parasitism it may be well to digress for a moment, in order to give some consideration to the part which environment plays in determining numerical status, or populations. It is fully appreciated that what I shall say about this subject is not new, but it seems necessary to emphasise it, because it is undoubtedly fundamental to the question under discussion, and furthermore I am convinced that its importance is often overlooked by entomologists dealing with biological control. The point which I desire to emphasise is that it is largely *environment*, and not *prolificacy*, which determines populations. It is very true, of course, that populations are influenced by the conflict between the environment, or environmental resistance, and prolificacy, or reproductive potential, as has long been recognised. That which needs to be clearly understood however, and which I believe is often overlooked, is that within reasonable limits every species, once firmly established in its environment, has a saturation point, which its population rarely or never exceeds, no matter what its reproductive potential may be. This is the point where certain factors in the environmental resistance become operative which cannot be overcome by reproductive potential. Good examples of such factors are abundant. A moth deposits its eggs in clusters several layers deep, and no matter how prolific and abundant *Trichogramma* may be, it can parasitise only the outer layer, upon which its saturation point is reached. The main factor which determines the saturation point here is the inaccessibility of all but the outer layer of eggs. The population of oak trees is determined, not by the abundance of acorns produced, which is more than ample under any conditions, but by the environmental resistance. It is obvious that this saturation point must occur in every species of organism, since it is the *sine qua non* of its existence. This applies, of course, only to species which are completely established in their habitat, and not to species which are still invading new territory.

For practical purposes then, and disregarding slight fluctuations, it may be said that prolificacy has little bearing on populations of completely established insects, these populations being limited, by the environmental resistance, at the saturation point for each species. Nature has endowed each with a reproductive potential which is more than ample to do this, under practically any conditions that may arise. The saturation point, and consequently the population, varies with changes in the amount of environmental resistance.

We may now return to a consideration of multiple parasitism, as manifested in the five categories designated above. Two factors are important in this connection: first, the outcome of the conflict between the two species within the same host; second, the saturation points of the two species, which are determined by the environment.

It is recognised that under these conditions of competition, the overlapping results in fewer parasites of the intrinsically inferior species reaching the adult stage. That is indisputable; but what we are interested in is, does such competition result in fewer adults of *both* species combined than would have been produced of a single species working alone?

It will be simpler to consider the different categories separately. Competition of the first order, that is "neither species is intrinsically or extrinsically superior," is fairly simple, and we may, in order to eliminate as many complications as possible, assume that the two species have exactly the same habits. Under these conditions, which it is admitted are purely hypothetical, it must be recognised by anyone who has given the matter any careful thought, that the total number of adults of both species produced will be exactly equivalent, *neither more nor less*, to the number which would have been produced by either species working alone. Such overlapping as occurs has its exact counterpart in the superparasitism that occurs within the single species. Such a situation probably never arises in nature, but if it should do so, there would be neither advantage nor disadvantage in introducing both species over a single one. The results would be exactly the same, so far as the production of adults is concerned. The two species might, however, be equivalent extrinsically, and yet occupy slightly different types of ecological niches. In such a case it is obvious that the two species would be of more value in the destruction of the host than would either one working alone.

In competition of the second order, "one species is intrinsically superior but neither species has any extrinsic superiority," since the intrinsically superior species always destroys the intrinsically inferior species, it can be shown that, if they occupy exactly the same kind of ecological niches, the former would in time completely replace the latter, but the total number of adults produced would remain the same as would have been the case if either species had been introduced alone. So that, in this case also, there would be neither advantage nor disadvantage in introducing both species. These examples are of academic interest only, since two species of parasites having exactly the same habits, and occupying exactly the same kinds of ecological niches, certainly occur very rarely, if ever. If, then, as is practically certain to be the case, the intrinsically inferior species occupies at least a *few* ecological niches not available to the other, the total production of adults by both species would exceed that of the intrinsically superior species by this amount, and the two species would be more effective than either species alone would have been.

In the third type, "one species is extrinsically superior but neither has any intrinsic superiority," the competition between the two within the host gives neither any advantage over the other and the ratio of adults of the two species produced is not affected by the competition. The species which is extrinsically superior will destroy the greater number of hosts, and the total number of hosts destroyed will be the sum of what each would destroy alone, less a certain amount of overlapping. Now the amount of this overlapping is determined entirely by the similarity of the ecological niches. If these niches are almost entirely dissimilar, there will be very little overlapping, this occurring only where they tend to occupy the same niches. The two species would be more effective than either one alone, and their introduction would be justified.

In the fourth type of multiple parasitism one species is "both extrinsically and intrinsically superior." Should the inferior species be introduced? Since it is

intrinsically inferior it cannot, through competition within the host, reduce the efficiency of the intrinsically superior species. It is evident, therefore, that the introduction of the inferior species can at least do no harm, but can it do any good? If it is assumed that the inferior species occupies only the ecological niches that the superior species would in any case occupy, nothing would be gained by such an introduction. If, however, it can occupy at least a few ecological niches that are inacessible to the superior species, it will to that extent be of value in the control of its host. That this often occurs is proven by the fact that these inferior species do survive in nature in competition with the superior species. It may be safely concluded then, that in this type of multiple parasitism there is no possibility of harm coming from the introduction of both species, and there is at least a good probability that it will be advantageous.

In type five, one species is " intrinsically superior but extrinsically inferior." This is the type of multiple parasitism about which there seems to be the most uncertainty in the minds of entomologists interested in biological control. The question is, does or does not the intrinsically superior but extrinsically inferior parasite so operate as to reduce the total number of hosts destroyed below the number that the extrinsically superior but intrinsically inferior species would have destroyed alone? Two considerations affect our conclusion regarding this point ; *i.e.*, the results of the competition itself on the adult parasites produced, and the question of ecological niches. In the competition within the host, the intrinsically superior parasite always survives and the other is destroyed. It is postulated, however, that this intrinsically inferior species is at the same time *extrinsically superior*. All this really means is that it occupies more ecological niches than the intrinsically superior species and, therefore, it would of necessity have to occupy some that were not occupied by the intrinsically superior species. The main question now arises : Will the introduction of both these species accomplish a greater destruction of the host than would have been accomplished by the introduction of the intrinsically inferior but extrinsically superior species alone? The writer believes, contrary to the conclusions of Pemberton and Willard, that the two species will accomplish greater destruction of the host than the extrinsically superior species would accomplish working by itself.

There are two factors which are of prime importance in the consideration of this question. These are the amount of overlapping that occurs between the two species, and the degree of extrinsic superiority which the one species has over the other. It is obvious that this competition can have no effect on the population of the intrinsically superior species, since it always survives the competition. Its efficiency, then, is unchanged and it will destroy the same percentage of hosts as it would if working alone. All we need to consider then is the effect on the intrinsically inferior species. Now the amount of overlapping is determined by the similarity of the ecological niches. If we assume that the ecological niches are entirely dissimilar, there would be no overlapping and the total number of hosts destroyed would be exactly the sum of what would be destroyed by each species working alone. As the degree of overlapping increases the total of hosts destroyed will decrease, but not in inverse proportion to the increase in overlapping, because, as the adults of the extrinsically superior species become reduced in number, the survival potential of their progeny presumably increases, so that there will be a greater proportion of hosts destroyed per parent parasite when the adults are scarce than there will be when they are abundant. Thus a material reduction in the number of parent parasites does not necessarily mean a corresponding reduction in the number of hosts destroyed by their progeny, so that this overlapping, unless it is very extensive, does not have any very close bearing on the number of hosts destroyed by the next generation.

Since it is postulated that one species is extrinsically superior to the other, it must be capable, therefore, of occupying at least a few ecological niches which are not available

to the other species, and those individuals occupying these niches cannot under any conditions be destroyed by competition. The greater the extrinsic superiority the greater will be the proportion of those individuals which escape destruction by competition.

The situation may be briefly summarised as follows: If the extrinsically superior species is *only slightly* superior and the ecological niches are very similar, there will be a large amount of overlapping and the extrinsically superior species will be greatly reduced in effectiveness. If we make this assumption, however, it would then be necessary to admit that nothing would be gained by limiting the introduction to the extrinsically superior species because its superiority over the other species is so slight as to make such limitation of no practical significance. If, however, the one species is greatly superior to the other extrinsically and the ecological niches are not entirely similar, a large percentage will escape destruction by competition and, although they are reduced in number below what would have been produced if this species were working alone, the increased survival potential tends to offset this reduction to a large extent. Practically as many hosts in each generation will be *attacked* by the extrinsically superior species as would have been attacked if it were working alone, although the number of the extrinsically superior species *reaching maturity* is lessened because they are destroyed by the other species through competition. Therefore, the number of hosts attacked by both species is approximately equal to the number which would have been attacked by the extrinsically superior species working alone, plus the number of hosts attacked by the other species which escape attack by the extrinsically superior species. All hosts attacked by the extrinsically inferior species *alone*, represent then a distinct gain in effectiveness of the two parasites over what would have obtained if only the extrinsically superior species had been introduced. It is concluded, therefore, that in spite of the fact that the extrinsically superior species is always destroyed by the extrinsically inferior species when they attack the same individual host, the two species working together will destroy a greater percentage of hosts than would have been destroyed by the extrinsically superior species working alone. The introduction of both species is, therefore, justified.

We may now return to the interesting study by Pemberton and Willard on the inter-relations of fruit-fly parasites in Hawaii and endeavour to determine wherein their conclusions seem to be unjustified. It is only because of the very great importance of this question to the future of biological control and because of the fact that many entomologists have accepted these conclusions as valid, that the writer is impelled to express here his disagreement with them. An enormous amount of interesting data has been accumulated by these authors and later by Willard alone, and these data are bound to prove very useful in the solution of this and other problems relating to biological control.

This study relates primarily to the behaviour of two Braconid parasites of the Mediterranean fruit-fly, *Opius humilis*, Silvestri, and *Diachasma tryoni*, Cameron, introduced into Hawaii by Silvestri in 1913. The introduction of these two brought about an interesting case of multiple parasitism, since both species attack the same stage of the host simultaneously. Where both species oviposit in the same individual host, *Diachasma* practically always destroys *Opius*, although *Opius* seems to be capable, at least during the greater portion of the year, of greater efficiency as a destroyer of fruit-flies. This case belongs to the "type five" manifestation of multiple parasitism designated previously, *Diachasma* being the intrinsically superior parasite and *Opius* the extrinsically superior species. The authors conclude, from the data presented, that the introduction of *Diachasma* was a serious mistake and that *Opius* working alone would accomplish greater destruction of fruit-flies than do both species working together. These conclusions are largely based on the fact that *Opius* is more prolific than *Diachasma* and, since when the two attack the same individual

host *Diachasma* practically always destroys *Opius*, the result is that a more prolific parasite is replaced by one of lesser prolificacy. Now if it could be shown that prolificacy is the thing which determines the efficiency of a parasite, one might be compelled to accept the conclusions as valid. If prolificacy, of itself, were *the important factor* in determining the efficiency of a parasite, the most prolific species would be the most abundant, and that is certainly not the case, as could be easily proven by hundreds of examples. It is only under extraordinary conditions, such as during the invasion of new territory by an insect, that prolificacy determines populations. There is not sufficient justification, therefore, in the writer's opinion, for the conclusion that *Opius* is necessarily more valuable than *Diachasma* because it is more prolific.

But, even though it be agreed that a parasite's efficiency is not directly proportional to its prolificacy, may it still not be true, as the authors believe, that when a more efficient parasite, *Opius*, is almost always replaced by a less efficient one, *Diachasma*, when they attack the same host, an injurious effect must follow? The writer believes not, for the following reason :—That which measures the efficiency of a parasite is the number of ecological niches which it is capable of occupying. Now under all ordinary circumstances a species will be able to produce progeny in excess of what is necessary to fill these niches, and a considerable destruction of either parents or eggs will still permit an ample supply of progeny for this purpose. It follows then, that unless *Diachasma* destroys a very large proportion of *Opius*, it would not seriously affect its ability to occupy most of the available ecological niches.

The following data submitted by Pemberton and Willard* are of interest : A total of 1,384 puparia of the fruit-fly was collected from coffee berries in the Kona district in April 1916 and January 1917. Of these, 124 or 8·9 per cent. produced *Diachasma* ; 236 or 17 per cent. were attacked by both *Diachasma* and *Opius*, in which case *Diachasma* practically always survived ; 688 or 48·1 per cent. produced *Opius* ; 320 or 23·1 per cent. were unparasitised ; and 16 or 2·9 per cent. were miscellaneous combinations. An inspection of these figures indicates that while only

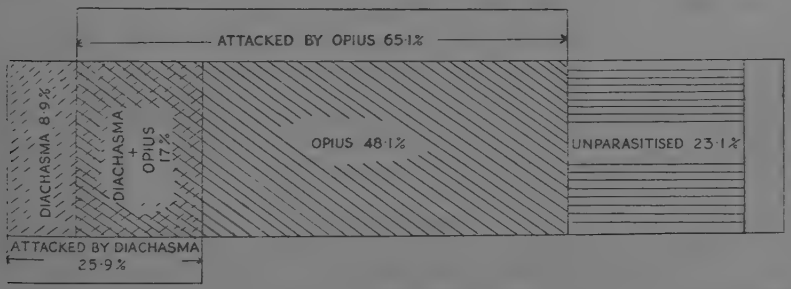



Fig. 1. Diagram representing multiple parasitism showing both percentage of hosts *attacked* and percentage *destroyed* by *Diachasma* and *Opius*, and percentage of overlaps, which in most cases produced *Diachasma*. Arranged from data submitted by Pemberton and Willard.

48·1 per cent. of the puparia *produced Opius*, a total of 65·1 per cent. were actually *attacked* by it, and one may be permitted to doubt whether this parasite, after it had become thoroughly adjusted to its environment, would have destroyed on the average more than 65·1 per cent. of the puparia when working alone. Even though the 17 per cent. of the puparia which were attacked by both species had produced *Opius* alone, it is extremely doubtful whether they would have had the effect of increasing the parasitism by *Opius* from 48·1 per cent. to more than 65·1 per cent. It is the writer's

* Op. cit., p. 290.

belief that the 65·1 per cent. about represents what *Opius* might be expected to parasitise when working alone at the time the observations were made, and that the destruction of the 8·9 per cent. by *Diachasma* about represents the superiority of the two species over what *Opius* working alone would have accomplished. That the additional *Opius* would have produced a materially higher percentage of parasitism may be questioned in view of the fact that the authors found as many as 10 *Opius* larvae in a single host, where only one can mature. Evidently it was not a shortage of parents which determined the percentage of parasitism.

In a later paper on the subject of fruit-fly parasitism Willard and Bissell* have collected the data on parasitism for the years 1915 to 1921 inclusive. These data indicate that the parasitism by *Opius* has gradually decreased, while that by *Diachasma tryoni* and *D. fullawayi* has increased. This is cited by the authors as proof of the contention that "*O. humilis*, being more prolific and capable of destroying a higher percentage of *C. capitata* under Hawaiian conditions than either species of *Diachasma*, would be more effective, working alone, than *O. humilis*, *D. tryoni* and *D. fullawayi* combined." I am unable to see how these conclusions are justified by the data presented. That this competition between parasites would operate to reduce the parasitism by *Opius humilis* there can be little question. That is apparently inevitable, but it does not necessarily follow, because the parasitism by *Opius* has decreased, that the total parasitism by the three species combined is less than would have been the case if *Opius* alone had been introduced. On the contrary, the data submitted show that the highest percentage of parasitism achieved by *Opius* was 31·5 in 1915, when the competition of the other species was almost negligible, while the combined parasitism by the three species in 1921 was 40 per cent. and in 1920 44·2 per cent. Furthermore, one is not justified in concluding that the decline in importance of *Opius* is due solely to the competition by the other species. I believe that that had a good deal to do with it, but I have too often seen newly introduced parasites, as well as phytophagous species, develop exuberantly for the first two or three years and then begin to decline when the biotic factors of their environment got into action, to feel safe in attributing such decline to any single factor.

The case for or against multiple parasitism is, of course, not proven, and will not be until extensive experiments under controlled conditions have been carried out. Such experiments are now under way, but they can only indicate the principles under which multiple parasitism operates. Because of the complexity of a parasite's environment, it is doubtful whether one could determine, from studies other than actual field observations, just how it would react in the open, and then it would be too late to make use of the knowledge gained.

One thing which seems to have confused the issue in the minds of some entomologists is failure to recognise the fact that in studying the progress of an introduced parasite one must divide the event into two periods. One is the period during which its population is increasing, the other is the period after it has become stabilised in its environment and the population has become constant (within the limits of normal fluctuation). During these two periods the same factors have a different effect on the populations. Prior to the time when a parasite has reached its saturation point, prolificacy *does* have an important bearing on the population and, other things being equal, it is true that the more prolific parasite may reach that point more quickly than the other. The destruction then, of a more prolific parasite by one of lesser prolificacy, through multiple parasitism, could theoretically have the effect of delaying the time when it reached a stable population. It does not, however, determine *where* the population will be stabilised, and once stability has been attained, the factor

* Work and Parasitism of the Mediterranean Fruit-fly in Hawaii in 1921. Jour. Agric. Res. xxxiii, pp. 9–15, 1926.

of prolificacy must be practically disregarded, since only a sufficient number of progeny mature to replace the parents and there is no increase. In biological control work we are only casually interested in the ability of the parasite to increase in numbers, but we are vitally interested in the *level* of the population, which is determined largely by environment, rather than by prolificacy. The destruction of a more prolific parasite by one of lesser prolificacy does not necessarily have a direct bearing on the population level, which is, after all, the important thing from an economic standpoint. The ability of an organism to increase rapidly in numbers is something different from its ability to maintain a high population level, and failure to recognise this distinction is a source of much confusion. It seems to the writer, however, that on theoretical grounds as well as on the data so far available, the policy of entomologists in introducing all available primary parasites of an injurious species is justified, and that this policy should be continued.

There is another factor in connection with multiple parasitism that is important and should not be lost sight of. This is the superior " balancing " effect that several species of natural enemies have over a single one. Sudden changes in environment often serve to reduce the efficiency of a parasite and cause extreme fluctuation in the abundance of its host, to the detriment of our crops, whereas if there are several species at work they are not all likely to be affected in the same degree, and some will step in and fill the gap left by the delinquent one. This tends strongly toward maintaining a constant population of phytophagous insects, as opposed to a fluctuating one.

# THE TSETSE-FLY PARASITES BELONGING TO THE GENUS *THYRIDANTHRAX* (DIPTERA.—FAMILY BOMBYLIIDAE), WITH DESCRIPTIONS OF NEW SPECIES.

By Major E. E. Austen, D.S.O.

The only Dipterous parasites of tsetse-flies at present known belong to the family Bombyliidae, and to the genus *Thyridanthrax*, O. Sack., as enlarged by the late Professor Bezzi. Hitherto the species of this genus definitely stated in literature to be parasitic in the larval stage in *Glossina* pupae consisted solely of *Th.* (*Villa*) *lloydi*, Austen, and *Th.* (*Anthrax*) *abruptus*, Lw. In the following pages the number of species of which specimens have been bred from pupae of tsetse-flies is raised to seven, including three species which are described below for the first time. With one exception (*Th. argentifrons*, sp. n.), in which the holotype emerged from a pupa of *Glossina tachinoides*, Westw., while a paratype was bred from a pupa of *G. morsitans*, Westw., form *submorsitans*, Newst., these flies are not known to attack any species of *Glossina* other than *G. morsitans*. Whether it will ever prove possible to make practical use of parasites for the purpose of tsetse-fly control, is a question for the future. In this connection, however, it is perhaps of interest to note that, whereas six out of the seven species dealt with below occur either in Rhodesia, or in countries to the south-east or north-east of that territory, the seventh species (*Th. argentifrons*) has been met with in Northern Nigeria.

It is hoped that the publication of the present paper may lead those who have the opportunity to pay increased attention to the breeding of Bombyliid tsetse-fly parasites. Whenever such parasites are bred out, special pains should be taken to preserve them undamaged. Many Exoprosopinae are damaged by rubbing almost as easily as are Bombyliinae, and, apart from wing-markings, such rubbing may cause a characteristic facies to be entirely altered.

## Subfamily Exoprosopinae.

### Genus **Thyridanthrax,** Osten Sacken (Bezzi emend)*.

*Key to the Seven Species of* Thyridanthrax *known to be parasites of Tsetse-flies* (Glossina).

1 (6). Wings entirely, or practically entirely hyaline, at any rate without any black or blackish brown area even at base ... (*Th. lloydi* Group).

2 (3). Front (frons), at least in ♂ anteriorly, silvery, clothed with shining, silvery-white scales; bands of scales or scale-like hairs on dorsum of abdomen forming sharp colour-contrasts ... ... *argentifrons*, sp. n.

3 (2). Front (frons) not silvery; bands of scales on dorsum of abdomen not forming sharp colour-contrasts.

4 (5). Front, at least in ♂, densely clothed anteriorly with fairly broad, yellowish white scales; lateral margins of dorsum of thorax, at least in ♂, clothed with white hair, forming a conspicuous stripe on each side; first posterior cell in wing narrowed at tip ... ... ... ... *salutaris*, sp. n.

*In the present paper, following the example of the late Prof. Bezzi, *Thyridanthrax*, as expanded by this author (*cf.* Bezzi, Transactions of the Entomological Society of London for the Year 1911, p. 625, 1912; and "The Bombyliidae of the Ethiopian Region," p. 192, 1924), is treated as a distinct genus, rather than, as by S. J. Paramonow ("Zur Kenntnis der Gattung *Hemipenthes* Lw."; Encylopédie Entomologique, II, Diptera, T. III, Fasc. 4, p. 150, 1927), as a subgenus of *Hemipenthes*, Lw.

5 (4). Front in both sexes clothed with a mixture of narrow, buff-coloured scales and short, black hair; lateral margins of dorsum of thorax clothed with yellowish white (♂) or yellowish (♀) hair; first posterior cell in wing not narrowed at tip ... ... ... ... ... *lloydi*, Austen

6 (1). Wings partly (if only at base, or on part of costal border as well) black or blackish brown (*Th. afer* Group).

7 (8). Black or blackish brown area in wings confined to base (as far as humeral transverse vein) and interspace between first longitudinal and auxiliary veins ... ... ... ... ... ... ... ... *lineus*, Lw.

8 (7). Black or blackish brown area in wings more extensive.

9 (10). Wings with anterior transverse vein unusually close to base of discal cell, *i.e.*, at about one-fifth of length of cell from its base; black or blackish brown area in wings, at least in ♂, extending from base to anterior transverse vein and origin of second longitudinal vein, not entering discal cell, but with a narrower extension between first longitudinal and costal veins, as far as tip of auxiliary vein ... ... *beneficus*, sp. n.

10 (9). Wings with anterior transverse vein not unusually close to base of discal cell; black or blackish brown area in wings (reaching from base of wing to tip of auxiliary vein) larger, extending into base of discal cell.

11 (12). Wings with black or blackish brown area scarcely, if at all, entering extreme base of fourth posterior cell, and differing markedly in shape in the two sexes (infuscation in marginal cell in ♂ scarcely extending beyond base of second longitudinal vein); larger species *abruptus*, Lw.

12 (11). Wings with black or blackish brown area usually extending well into base of fourth posterior cell, agreeing in shape in the two sexes, and in marginal cell reaching well beyond base of second longitudinal vein in both ♂ and ♀; small species ... ... ... ... *transiens*, Bezzi.

*Th. lloydi* Group.

**Thyridanthrax lloydi,** Austen (figs. 1 and 2*a*).

Fig. 1. *Thyridanthrax lloydi*, Austen, ♂, ×9.

*Villa lloydi*, Austen, Bull. Ent. Res., v, pt. 1, p. 92, fig. 1, April, 1914; Lloyd, *ibid.*, vii, pt. 1, pp. 76,77, fig. 2 (larva and pupa), May, 1916; Austen and Hegh, "Tsetse-Flies, their Characteristics, Distribution and Bionomics, with some account of Possible Methods for their Control," pp. 120, 130, 131, figs. 9, 10, 1922; Hegh, "Les Tsé-Tsés," pp. 713, 714, figs. 320, 321 (Bruxelles: Imprimerie Industrielle et Financière. 1929).

*Thyridanthrax lloydi*, Bezzi, "The Bombyliidae of the Ethiopian Region," p. 192, 1924.

In addition to the type of this species, a male, which is from NORTHERN RHODESIA (Mpika Division, Ngoa, between 15.ix. and 18.x.1913. *Ll. Lloyd.* Bred from pupa of *Glossina morsitans*, Westw.), the British Museum, thanks to the courtesy of the Imperial Bureau of Entomology, now possesses three ♀♀ of *Th. lloydi*, all bred by Dr. Lloyd at Ngoa, 18–30.ix.1915, from pupae of *Glossina morsitans*, Westw. The specimens are accompanied by their puparia and by those of *G. morsitans* from which their pupae emerged. The chitinous teeth on the underside of the head-capsule in the puparium of *Th. lloydi* (*cf.* Austen, Bull. Ent. Res., v, pt. 1, p. 91, note*, April 1914) are large, prominent and very conspicuous—much more so than the corresponding teeth in the case of the puparia of, e.g., *Th. lineus*, Lw., or *Th. abruptus*, Lw. Dr. Lloyd (*loc. cit.*) writes: "The pupa has a rounded head armed with three pairs of strongly chitinised tubercles. The first segment of the abdomen bears dorsally a fringe of long stiff hairs directed backwards, these being replaced on the

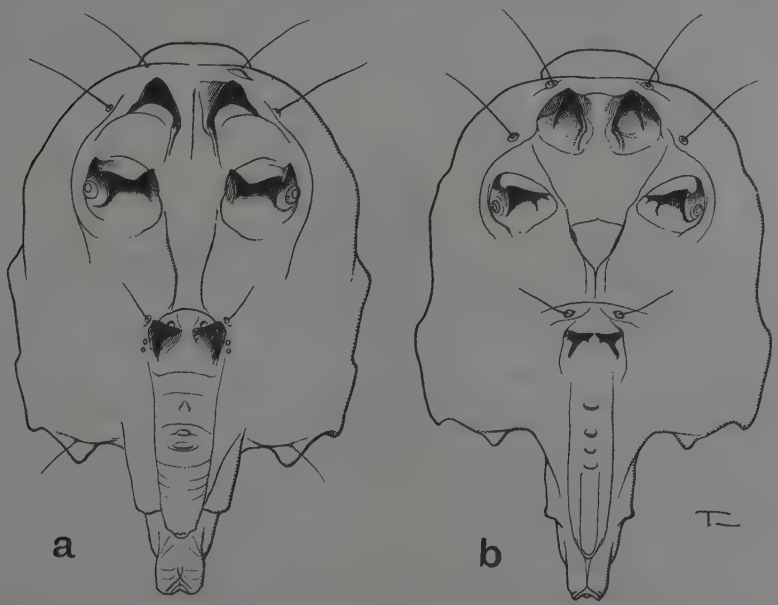



Fig. 2. Head-capsule of puparium, ventral aspect, showing chitinous teeth: *a*, *Thyridanthrax lloydi*, Austen; *b*, *Th. argentifrons*, sp. n.

remaining segments by short recurved hooks, with a few hairs. The third pair of legs protrude as stout pegs. The pupa bursts out of the tsetse puparium anteriorly and works its way up to the surface of the ground by means of the long fringe of hairs, which are alternately raised and depressed, the peg-like legs acting as a fulcrum. On the surface it becomes quiescent, elongates, splits along the dorsal surface, and the fly emerges, being ready for flight almost at once. The time from the cessation of movement of the pupa to the flight of the fly occupies only two or three minutes. . . . This species, taken at Ngoa, is apparently identical with *Villa lloydi*, Aust., which was taken in the same locality in 1913. Three specimens of the perfect insect were obtained on this occasion, and its pupa was taken three times in puparia broken in collecting. The pupae were collected in September, and the flies emerged in the same month."

**Thyridanthrax salutaris,** sp. nov. (fig. 3*a*).

♂.—Length (one specimen) 6·2 mm.; width of head 2·25 mm.; width of front at vertex *circa* 0·4 mm.; length of wing 6·4 mm.

Belonging to the *Th. lloydi* Group (=subgenus *Exhyalanthrax*, Becker).—*In general appearance resembling* Thyridanthrax (Villa) lloydi, *Austen, but differing in having a more prominent face, paler and broader scales on the front, a differently marked abdomen, and somewhat differently shaped first posterior and discal cells.*

*Head* dark greyish-olive ;* front (frons) densely clothed anteriorly with fairly broad, yellowish white scales, which extend downwards between bases of antennae ; front clothed above with narrow, glistening, ochraceous-buff scales, and with a mixture of yellow and black, short, erect hairs; face prominent, conical, clothed with small,

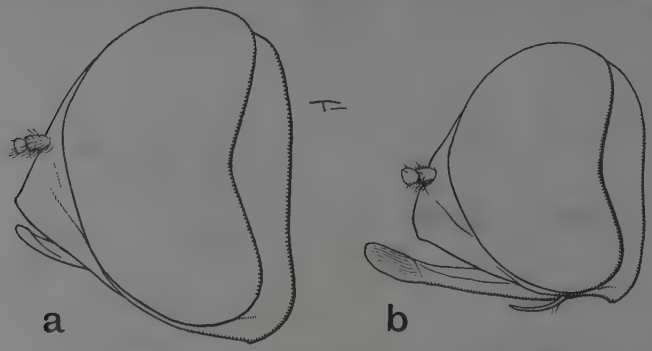



Fig. 3. Head of ♂ in profile : *a*, *Thyridanthrax salutaris*, sp. n. ; *b*, *Th. argentifrons*, sp. n.

glistening, ochraceous-buff scales ; posterior orbits clothed with silvery-white scales ; *proboscis* blackish brown ; first and second segments of *antennae* black, clothed with black hair (third segment missing in case of type). *Thorax* : dorsum of main portion (scutum), except front margin and lateral borders, clothed with ochraceous-orange, appressed, narrow scales or flattened hairs ; fringe of erect hair on front margin of dorsum ochraceous-buff, lateral borders of scutum, including postalar calli, clothed with white hair, each postalar callus with a pair of long, fine, backwardly-directed, black bristles ; dorsal surface of scutellum, except hind border, clothed with ochraceous-orange scales, hind border of scutellum clothed with narrow white scales, and bearing a series of long black bristles ; pleurae deep mouse-grey, clothed for most part with ochraceous-buff hair. *Abdomen* : basal angles of dorsum (*i.e.*, lateral extremities of first and basal angles of second tergite) clothed with outstanding white hair ; remainder of dorsum, except as stated below, clothed with appressed, ochraceous-orange scales ; second tergite with some whitish scales on fore border, towards lateral extremities ; seventh tergite and anterior half of sixth clothed with white scales ; lateral thirds of anterior border of third tergite clothed with white scales or similarly coloured hair ; some whitish, or at any rate paler scales towards lateral extremities of fourth tergite ; venter clothed with ochraceous-orange scales or scale-like hairs, intermingled with long, outstanding, light ochraceous-buff hairs. *Wings* : extreme base, as far as humeral transverse vein, drab ; wings otherwise, except for a tiny, greyish fleck in upper distal angle of second basal cell, entirely hyaline ; auxiliary and first and fifth longitudinal veins cinnamon-buff, veins other-

* For names and illustrations of colours used for descriptive purposes in the present paper, *see* Ridgway, " Color Standards and Color Nomenclature " (Washington, D.C. Published by the Author, 1912).

wise mainly mummy-brown or cinnamon-brown; base of costa with minute, ochraceous-orange scales interspersed among stiff black hair; fourth vein curving steeply downwards to form distal extremity of discal cell, first posterior cell conspicuously narrowed at tip. *Halteres*: distal halves of knobs cream-buff, halteres elsewhere light ochraceous-tawny. *Legs*: ground-colour largely cinnamon-buff, clothed with light ochraceous-buff scales; bristles on middle and hind legs black.

NYASALAND PROTECTORATE: Lingadzi (near Domira Bay, Lake Nyasa), 1,700 feet, 17.viii.1915 (*Dr. W. A. Lamborn*). Holotype ♂ bred from pupa of *Glossina morsitans*, Westw., taken 3.viii.1915. Presented by the Imperial Bureau of Entomology.

The puparium of the holotype is 6·16 mm. in length, and measures 2·4 mm. in its greatest depth dorso-ventrally. The chitinous teeth on the underside of the head-capsule resemble those on the puparium of *Th. argentifrons*, Austen, sp. n. (*vide infra*), and are much smaller, blunter and less prominent than the corresponding teeth on the puparium of *Th. lloydi*, Austen; the middle pair of teeth are not trifid, but somewhat pyramidal.

Fig. 4. *Thyridanthrax argentifrons*, sp. n., ♂, ×10.

**Thyridanthrax argentifrons,** sp. nov. (figs. 2*b*, 3*b*, 4 and 5).

♂.—Length (one specimen) 5·2 mm.; width of head 1·8 mm.; width of front at vertex *circa* 0·25 mm.; length of wing 5·4 mm.

Belonging to the *Th. lloydi* Group (=subgenus *Exhyalanthrax*, Becker).—*Black; a pretty little species, with body narrower and more cylindrical than in* Th. (Villa) lloydi, *Austen, and, at any rate in* ♂, *with posterior orbits and at least anterior three-fifths of front* (*frons*) *conspicuously clothed with glistening, silvery-white scales; dorsum of abdomen, as shown in* fig. 4, *with sharply defined, alternating, transverse, ochraceous-buff, silvery-white, and black bands, composed of narrow, elongate scales; last abdominal tergite, as also penultimate tergite to a large extent, clothed with silvery-white scales; wings, except subcostal cell apart from its extreme tip, entirely hyaline.*

*Head* black, occiput thinly slate-grey pollinose; front between ocellar tubercle and commencement of covering of silvery-white scales sparsely clothed with fine,

erect, yellowish hairs ; silvery-white scales on front smaller and sparser above, larger and densely packed below, where they form prolongation between bases of antennae ; rather more than one-third of front, commencing a little below anterior end of upper third, clothed not only with scales but with short, whitish or yellowish-white, anteriorly directed hair ; parafacials bare ; face (*cf.* fig. 3*b*) bluntly conical, clothed, like margins of buccal cavity, with Naples yellow, flattened hairs or scales, mixed with minute black hairs ; *proboscis* and *palpi* clove-brown ; *antennae* black, first and second segments clothed with stiff black hair, longer on first than on second segment, first segment twice as long as second (third segment missing in case of type). *Thorax* : dorsum of main portion (scutum), except front margin and lateral borders, clothed with fine, appressed hair, ochreous in front and whitish posteriorly ; fringe of erect hair on front margin of dorsum ochreous, lateral borders of scutum in front of postalar calli clothed with white hair, postalar calli clothed with appressed whitish hair, and each postalar callus with a row of long, backwardly-directed bristles, black in front, cream-buff behind ; scutellum clothed above with minute, appressed hairs or narrow scales, ochreous on front border, elsewhere whitish, hind margin of scutellum with a fringe of long, fine, widely separated and backwardly-directed, black bristles ; propleurae fringed partly with black, partly with ochreous hair ; mesopleurae iron-grey pollinose, on upper order with a prominent tuft of ochreous hair, clothed elsewhere with glistening, pale yellowish hairs ; metapleurae with prominent fringes of whitish hair. *Abdomen* : dorsum adorned as follows with sharply defined, transverse bands formed by narrow, elongate scales ; first tergite with a silvery-white band occupying its posterior half ; second tergite with rather less than its anterior half, except extreme lateral extremities, which are clothed with silvery-white scales, occupied by a band of ochraceous-buff scales ; remainder of second tergite entirely black ; third tergite with its hind border black, elsewhere silvery-white, except that the silvery-white band has a narrow posterior edging of ochraceous-buff scales, which may or may not reach lateral extremities of tergite ; fourth tergite ochraceous-buff, except hind border, which is black ; fifth tergite mainly black, but with some ochraceous-buff scales in middle ; sixth tergite with hind margin black and fringed, like lateral extremities of hind margins of fourth and fifth tergites, with black hairs, elsewhere sixth tergite silvery-white, but with some ochraceous-buff scales on middle third ; seventh tergite silvery-white and bearing yellowish hairs ; lateral extremities of first tergite (*i.e.*, basal angles of abdomen) densely clothed with outstanding white hair ; venter clothed for most part with whitish scales, mixed, especially at base, with long, sparse, yellowish hairs. *Wings* : veins dark mummy-brown, except at extreme base where, with exception of costa, they are cinnamon-buff ; apical dip in second longitudinal vein of moderate depth (shallower than in case of *Thyridanthrax lloydi*, Austen) ; a faint infuscation immediately below base of third longitudinal vein ; subcostal cell as far as tip of auxiliary vein mummy-brown. *Halteres* light buff. *Legs*, as also bristles on middle and posterior pairs black ; middle coxae bearing a few black hairs ; hind coxae with yellowish hairs on outer side ; hind femora on outer and extensor surfaces clothed with blackish mixed with yellowish scales.

Northern Nigeria : Sherifuri (near Azare), iv.1928. Holotype ♂ bred from pupa of *Glossina tachinoides*, Westw. ; one ♂ paratype* bred from pupa of *Glossina morsitans*, Westw., form *submorsitans*, Newstead. Holotype and paratype obtained by *Dr. V. B. Wigglesworth*, and presented to the British Museum by the Imperial Bureau of Entomology.

In each case the fly, accompanied by the puparium from which it had emerged, was found by Dr. Wigglesworth lying dead on a plug of cotton wool inside a glass tube, in which he had previously placed a number of tsetse-fly pupae belonging respectively to the species mentioned above. The *Glossina* pupae in each tube were covered with

* The head of this specimen, while under examination, was unfortunately lost.

a pledget of cotton-wool some three-quarters of an inch thick, and the Bombyliid pupa, after making its escape from the tsetse puparium, had worked its way, doubtless between the wool and the glass, on to the top of this obstacle.

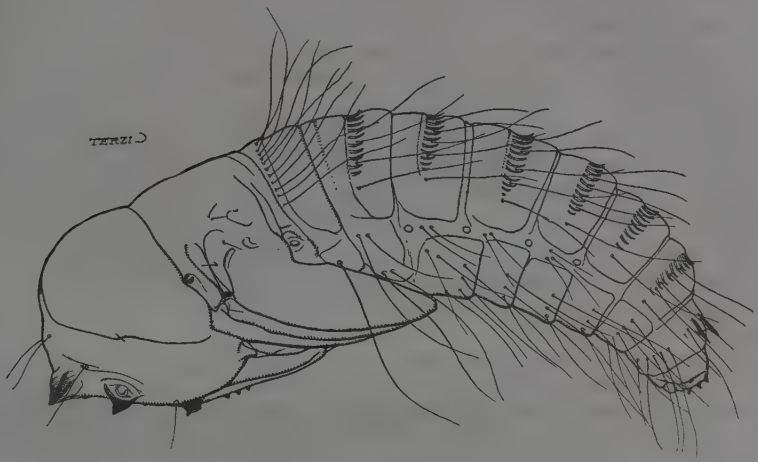


Fig. 5. *Thyridanthrax argentifrons*, sp. n., puparium, ×17.

The *puparium* (fig. 5) of the present species is considerably smaller than that of *Th. lloydi*,* its greatest width being only 1·8 instead of 2·6 mm.; the middle pair of chitinous teeth on the underside of the head-capsule (see fig. 2*b*) are not conspicuously trifid, as they are in the case of the puparium of *Th. lloydi*, and the teeth forming the posterior pair (that on the proboscis sheath) are closer together.

*Th. afer* Group.

**Thyridanthrax abruptus,** Lw. (figs. 6*a*, 7*a*, 7*b*).

*Anthrax abrupta*, Loew, Öfversigt af Kongl. Vetenskaps-Akademiens Förhandlingar, Årg. 17, p. 90, 1860; Abhandlungen des Naturwissensch. Ver. für Sachsen u. Thüringen in Halle, II. Bd. ("Die Dipteren-Fauna Südafrika's"), p. [291] 219, Tab. II, fig. 20 (*sic* :—*recte* fig. 21), 1860.

*Anthrax lugens*, Loew, Öfversigt af Kongl. Vetenskaps-Akademiens Förhandlingar, Årg. 17, p. 91, 1860; Abhandlungen des Naturwissensch. Ver. für Sachsen u. Thüringen in Halle, II. Bd. ("Die Dipteren-Fauna Südafrika's"), p. 220 [292], Tab. II, fig. 21 (*sic* :—*recte* fig. 20), 1860. [New synonym.]

*Thyridanthrax abruptus*, Lamborn, Bull. Ent. Res., vi, pt. 3, p. 256, December 1915; Austen and Hegh, "Tsetse-Flies, their Characteristics, Distribution and Bionomics, with some account of Possible Methods for their Control," pp. 120, 126–127, 130, 131, 1922; Bezzi, "The Bombyliidae of the Ethiopian Region," p. 202, 1924; Hegh, "Les Tsé-Tsés," p. 712 (Bruxelles: Imprimerie Industrielle et Financière, 1929).

*Thyridanthrax lugens*, Bezzi, *loc. cit.*, 1924. [New synonym.]

* *Cf.* Austen, Bull. Ent. Res., v, pt. 1, p. 91, footnote, April 1914; and Lloyd, *ibid.*, vii, pt. 1, p. 76, fig. 2*c*, May 1916.

"South Africa"; Natal; Southern Rhodesia; Northern Rhodesia; Nyasaland Protectorate; Uganda; Kenya Colony; Abyssinia.*

Among the series of specimens of the present species in the British Museum from the above-mentioned countries, there are six ♀♀—one from Southern Rhodesia, one from Northern Rhodesia, and four from Nyasaland, all of which were bred from pupae of *Glossina morsitans*, Westw. In some cases these specimens are accompanied by their puparium, and (or) that of the tsetse from which they emerged. The first of these six parasites to be received at the Museum emerged at Salisbury, Southern Rhodesia, in the middle of November 1912, in a jar containing a number of pupae of *Glossina morsitans*, Westw., found under a clump of trees in the Sebungwe District, S. Rhodesia, in September 1912 (*Dr. F. O. Stohr*: presented by Mr. R. W. Jack). The data as to the other specimens bred from pupae of *G. morsitans* are as follows. Northern Rhodesia: Chutika, 18.viii.1915 (*Dr. Ll. Lloyd*); one ♀, with its puparium, Nyasaland Protectorate: Lake Nyasa, Monkey Bay; one ♀, 1915 (*Dr. W. A. Lamborn*), with puparium of *G. morsitans* from which it emerged; one ♀, 11.v.1915 (*Dr. W. A. Lamborn*), with its puparium (*G. morsitans* pupa taken 7.v.1915); one ♀, 14.vii.1915 (*Dr. W. A. Lamborn*), with puparium of *G. morsitans* from which it emerged; one ♀, 26.vii.1915 (*Dr. W. A. Lamborn*), with its puparium and that of the tsetse parasitised by it.

The type, a female, of *Thyridanthrax abruptus* (*Anthrax abrupta*) is stated by Loew to be from "Caffraria" (Caffrerei). In this specimen, which Professor Yngve Sjöstedt has most courteously forwarded to the writer for study, the first antennal segment is black, as is also the case in ♀ specimens of this species in the National Collection from "South Africa," Natal, Nyasaland, Uganda, Kenya Colony and Abyssinia. In the

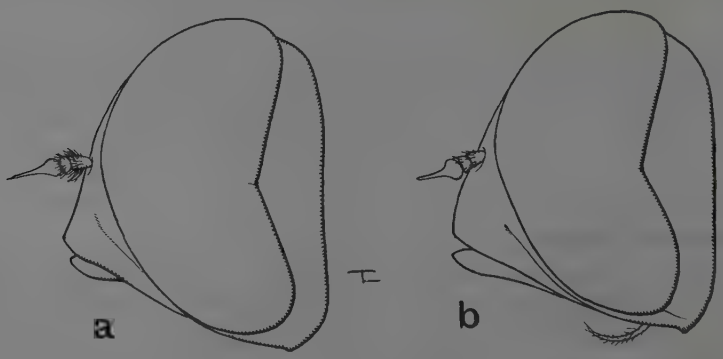



Fig. 6. Head of ♂ in profile: *a*, *Thyridanthrax abruptus*, Lw.; *b*, *Th. transiens*, Bezzi.

only ♂ from Nyasaland (S. Nyasa, Fort Johnston, 2,000 ft., 8.vi.1910, *Dr. A. H. Barclay*) in the collection, however, as also in a ♂ and ♀ from Northern Rhodesia (Chutika, 8 and 18.viii.1915. *Dr. Ll. Lloyd*), in a ♀ from Southern Rhodesia (Angwa River, x.1922. *S. Rhodesia Department of Agriculture*), and in a ♂ from Kenya Colony (Kitui. *S. W. J. Scholefield*) the first, as also the second segment of the antenna is cinnamon-buff or isabella-coloured; the same colour is also visible

* The record "N. Nigeria" for this species (Marshall, Bull. Ent. Res., vi, pt. 3, p. 256, note*, December 1915; and Bezzi, *loc. cit.*, 1924) rests on an error in identification; the ♀ specimen referred to by Dr. Marshall (N. Nigeria: Minna, 18.x.1910. *Dr. J. J. Simpson*) presents such differences in wing-marking as, in the writer's opinion, to prevent it from belonging to *Th. abruptus*, Lw.

on the underside of the base of the third antennal segment in the ♂ from Fort Johnston, Nyasaland.

The " very different venation " of *Thyridanthrax " lugens "* referred to by Bezzi (*loc. cit.*) appears to have no real existence, such differences of this kind as are exhibited by particular specimens being simply due to individual variation. On the other hand, within the limits of *Th. abruptus*, Lw., there is considerable variation in the shape of the distal extremity of the wing-marking adjacent to the costal margin. In the type (*cf.* fig. 7*a*) this extremity is as described by Loew, the distal margin of the

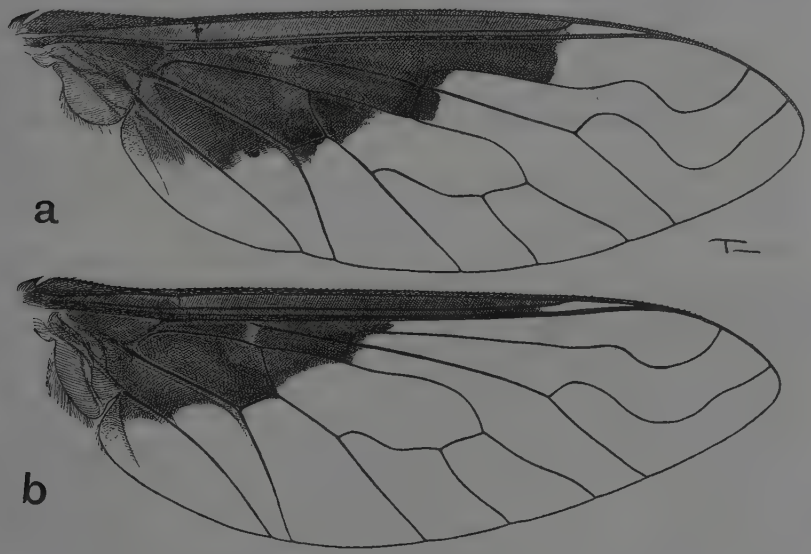



Fig. 7. *Thyridanthrax abruptus*, Lw.: *a*, wing of (type) ♀; *b*, wing of ♂.

dark brown or black area running straight from almost the extreme tip of the auxiliary vein to the second longitudinal vein, which it meets practically at right angles. In the ♀ in the National Collection from " South Africa " (Before 1844. *Dr. Andrew Smith*) the wing-marking on the costal border also terminates in the same way, except that the distal margin is slightly further from the tip of the auxiliary vein; in two ♀♀ from Natal, the distal extremity of the wing-marking, while terminating abruptly, is still further from the end of the auxiliary vein; in a ♀ from N. Uganda (Morongole, 6.ix.1913. *Dr. H. B. Owen*), and another from Kenya Colony (Oyani Stream, Kenyamkago, 16.xii.1911. *Dr. B. W. Cherrett*), the interval between the end of the wing-marking and the tip of the auxiliary vein is even greater, and ♀♀ from Rhodesia, Nyasaland and Abyssinia are, as regards their wing-markings, more or less of this type. In the three ♂♂, however, of *Th. abruptus* in the National Collection, from Northern Rhodesia, Nyasaland and Kenya Colony respectively (see above), the infuscation in the marginal cell scarcely extends beyond the base of the second longitudinal vein, with the result that in the costal and subcostal cells there is a long, narrow extension of the infuscated area, reaching to the end of the auxiliary vein (*cf.* fig. 7*b*).

The puparium of the present species measures some 6·4 to 6·6 mm. in length, by 2·5 mm. in greatest depth dorso-ventrally. The chitinous teeth on the underside of

the head-capsule resemble those on the puparium of *Th. salutaris*, Austen, being much less powerfully developed than the corresponding teeth on the puparium of *Th. lloydi*, Austen.

**Thyridanthrax transiens,** Bezzi (figs. 6*b* and 8).

" The Bombyliidae of the Ethiopian Region " p. 203, 1924.

Included in the series of *Th. transiens* in the National Collection are two ♂♂ from the Nyasaland Protectorate (Lingadzi, near Domira Bay, 18, 19.vi.1915. *Dr. W. A. Lamborn*), each of which was bred from a pupa of *Glossina morsitans*, Westw.

Bezzi (*loc. cit.*) is in error in stating that there is a band of white scales at the base of the *second* abdominal segment in this species, such white scales as there are at the base of the segment in question being confined to the lateral extremities. The following description of *Th. transiens* is intended to supplement Bezzi's original characterisation of the species.

♂♀.—Length, ♂ (three specimens) 4 to 6 mm., ♀ (one specimen) 5·25 mm. ; width of head, ♂ 1·4 to 2 mm., ♀ 1·6 mm. ; width of front at vertex, ♂ *circa* 0·25 mm., ♀ *circa* 0·4 mm.; length of wing, ♂ 3·8 to 6 mm., ♀ 5·5 mm.

Belonging to the *Th. afer* Group.—*Face* (*cf.* fig. 6*b*) *conical* ; *dorsum of thorax clothed largely with cinnamon-buff scales, and along each side with a conspicuous longitudinal stripe formed by white hair* ; *dorsum of abdomen, apart from lateral extremities of base, clothed partly with ochraceous-orange, partly with black, and partly with white scales, forming transverse bands* ; *wings*, as shown in fig. 8, *with a sharply defined clove-brown or blackish brown area at base, distal margin of which is irregular and runs obliquely from middle of axillary cell to end of auxiliary vein, wings elsewhere hyaline* ; *first posterior cell wide open, not at all contracted distally.*

*Head* : face and front olivaceous-black, occiput dark greyish olive, face and front clothed with minute, glistening, ochraceous-orange scales, mixed with short black hair ; posterior orbits clothed laterally with minute, silvery-white scales, occiput clothed elsewhere, at least on sides and above, with minute ochreous hairs ; *proboscis* and *palpi* blackish brown ; *antennae* (*cf.* fig. 6*b*) black, first and second segments clothed with short black hair, third segment somewhat abruptly narrowed beyond base, its distal portion forming a relatively long, tapering style. *Thorax* : ground-colour olivaceous black ; fringe of erect hair on front margin of dorsum ochraceous-buff ; cinnamon-buff scales on dorsum of main portion (scutum) mixed with minute black scales or scale-like hairs ; scutellum clothed above with cinnamon-buff scales ; postalar calli, as also hind border of scutellum, bearing usual long, black, backwardly-directed bristles ; pleurae clothed mainly with ochraceous-buff hair, propleurae clothed partly with ochraceous-buff, partly with black hair, metapleurae each with an outstanding fringe of silvery-white hair. *Abdomen* : ground-colour olivaceous-black ; lateral extremities of first tergite clothed with outstanding white hair, and with some erect, ochreous hairs on inner side of each patch of white hair ; elsewhere first tergite clothed mainly with ochraceous-orange scales, mixed in middle with black scales ; second tergite, except fore border, clothed mainly with black scales, basal angles of second tergite and lateral extremities of its fore border clothed with silvery-white scales and hair, fore border of second tergite otherwise clothed with ochraceous-orange scales, similar scales also forming a more or less complete transverse band across middle of tergite ; posterior halves of lateral borders of second tergite clothed partly with ochreous, partly with black hair ; fore border of third tergite clothed, more deeply in ♂ than in ♀, with silvery-white scales ; elsewhere third tergite clothed mainly with ochraceous-orange scales, but also with black scales on middle region towards hind margin ; fore borders of fourth and fifth tergites, also hind borders narrowly, clothed with black scales, fourth and fifth tergites otherwise clothed with ochraceous-

orange scales; sixth tergite clothed anteriorly with silvery-white, and posteriorly with ochraceous-orange scales; seventh tergite clothed with silvery-white scales; lateral extremities of third and fourth tergites in ♂ bearing partly black, partly pale hairs, lateral extremities of following tergites in ♂ bearing yellowish or whitish hairs; hairs on lateral extremities of third and following tergites in ♀ mainly black; venter

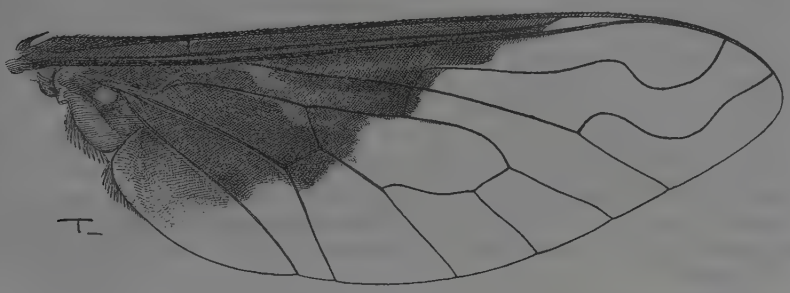


Fig. 8. *Thyridanthrax transiens*, Bezzi, wing of ♂.

in both sexes clothed with ochraceous-orange scales and long, yellowish hair. *Wings*: clove-brown or blackish brown area at base shaped as shown in fig. 8; costa with tuft of ochraceous-orange scales at base. *Halteres* light ochraceous-buff or pale ochraceous-buff. *Legs* black, femora and tibiae, at least middle and hind pairs, largely clothed with ochraceous-buff or light ochraceous-buff scales.

In addition to occurring (as stated by Bezzi) in Nyasaland and Southern Rhodesia, this species is also found in Kenya Colony, whence the British Museum possesses a ♂ from Kabete, iii.1922 (*H. E. Box*), and a ♀ from Embu, 20.iii.1914 (*G. St. J. O. Browne*.—Presented by the Imperial Bureau of Entomology).

Apart from its much smaller size, *Th. transiens*, Bezzi, differs from *Th. abruptus*, Lw., in the shape of the clove-brown or blackish brown area in the wing; in *Th. transiens* this area extends considerably further into the discal, fourth posterior and axillary cells, as also usually into the anal cell; thus in *Th. transiens* the infuscated area is broader at the base in proportion to its length than is the corresponding area in the wing of *Th. abruptus*. Again, in the ♂ sex there is no long, narrow extension of the infuscated area next the costa, from the level of the base of the second longitudinal to the tip of the auxiliary vein, as in the ♂ of *Th. abruptus*.

**Thyridanthrax lineus,** Lw. (figs. 9*a* and 10*a*).

*Anthrax linea*, Loew, Öfversigt af Kongl. Vetenskaps-Akademiens Förhandlingar, Årg. 17, p. 91, 1860; Abhandlungen des Naturwissensch. Ver. für Sachsen u. Thüringen in Halle, II. Bd. ("Die Dipteren-Fauna Sudafrika's"), p. 222 [294], 1860.

*Thyridanthrax lineus*, Bezzi, "The Bombyliidae of the Ethiopian Region," p. 201, 1924.

In this member of the *Th. afer* group, only the extreme base of the wings, as far as the humeral transverse vein and the bases of the basal, anal and axillary cells, as also the narrow interspace between the first longitudinal and auxiliary veins as far as the tip of the latter, are black or blackish brown (*cf.* fig. 10*a*); otherwise the wings are hyaline.

All the examples of this species in the National Collection, of which the sex is determinable, are ♂♂. The British Museum series of *Th. lineus*, of which the type was taken in "Caffraria," includes thirteen specimens from Nyasaland (Dowa District, and Monkey Bay, Lake Nyasa, 1.vi.—27.vii.1915. *Dr. W. A. Lamborn*), all of which were bred from pupae of *Glossina morsitans*, Westw. The puparium of *Th. lineus* measures rather more than 7 mm. in length, by some 2·5 mm. in greatest depth dorso-ventrally; the chitinous teeth on the underside of the head-capsule are small, not very prominent and in the form of transverse ridges; the teeth on the proboscis-sheath are so close together as to be in contact.

Apart from the locality of the type, referred to above, the range of *Th. lineus*, as shown by specimens in the National Collection, extends at least from Natal to Kenya Colony, while according to Bezzi (*loc. cit.*) the species has been recorded from Eritrea. In addition to the series from the Nyasaland Protectorate, and a specimen from Natal mentioned by Bezzi, the Museum Collection contains the following: one specimen (head missing—sex indeterminable), Natal, Weenen, xii.1923 (*H. P. Thomasset*); one ♂, S. Rhodesia, Angwa River, ix.1922 (*S. Rhodesia Department of Agriculture*); one ♂, Kenya Colony, Oyani Stream, Kenyamkago, 16.xii.1911 (*Dr. B. W. Cherrett*).

**Thyridanthrax beneficus,** sp. nov. (figs. 9*b* and 10*b*).

♂.—Length (one specimen) 5·4 mm.; width of head 2 mm.; width of front at vertex *circa* 0·2 mm.; length of wing 6 mm.

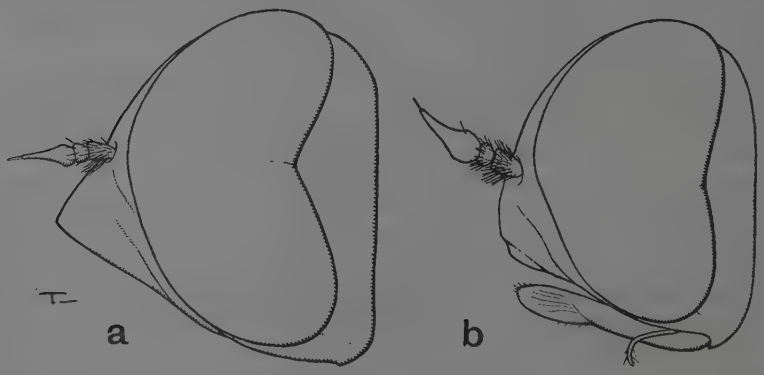



Fig. 9. Head of ♂ in profile: *a*, *Thyridanthrax lineus*, Lw.; *b*, *Th. beneficus*, sp. n.

Belonging to Bezzi's *Th. afer* Group.—*Except in size, superficially presenting considerable resemblance to* Thyridanthrax viduatus (Anthrax viduata), Lw.,* *but distinguishable,* inter alia, *by the face being only bluntly protuberant instead of pointed, and, as regards wing markings* (cf. fig. 10*b*), *by the infuscation in the marginal cell being confined to the extreme base, and not extending beyond the origin of the second longitudinal vein.—Black: front* (*frons*) *clothed with whitish scales, mixed with short, erect black hairs; dorsum of abdomen clothed for most part with black scales, but with a conspicuous transverse band of white or silvery-white scales occupying anterior half of third segment; wings with a tapering, dark mummy-brown stripe on fore border, shaped as shown in* fig. 10*b and not extending beyond tip of auxiliary vein.*

* For the opportunity of examining the type of this species the writer is indebted to the courtesy of Prof. Yngve Sjöstedt, of Riksmuseet, Stockholm, who most obligingly forwarded the specimen to London for study.

*Head* black, occiput thinly slate-grey pollinose; face (*cf.* fig. 9*b*) clothed with yellowish (ochreous) scales, posterior orbits clothed with silvery-white scales; *proboscis* and *palpi* blackish brown; *antennae* black, first and second segments clothed with stiff black hair, third segment, seen in profile, fairly broad (deep) at base, then tapering to an elongate point. *Thorax*: dorsum of main portion (scutum), except front margin and lateral borders, clothed with short, fine, appressed, ochraceous-buff hair; fringe of erect hair on front margin of dorsum ochreous, lateral borders of scutum in front of postalar calli clothed with white hair; hind margin of scutellum bearing a series of long, black bristles, postalar calli also with black bristles; propleurae fringed partly with black, partly with whitish hair; mesopleurae clothed above with ochreous hair. *Abdomen*: basal angles of dorsum (*i.e.*, lateral extremities of first and basal angles of second tergite) clothed with outstanding whitish hair; tip of dorsum—or at least anterior border of sixth tergite—clothed largely with silvery-white scales. *Wings* (*cf.* fig. 10*b*), apart from tapering mummy-brown stripe occupy-

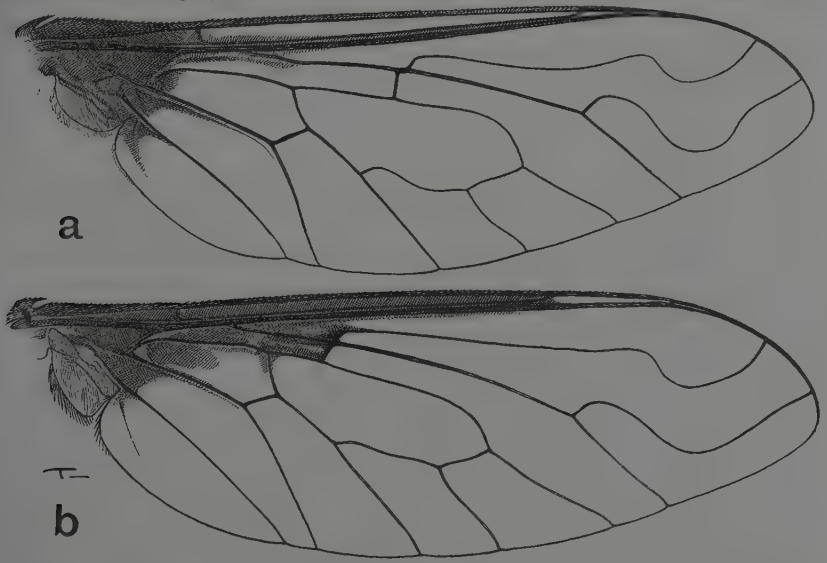



Fig. 10. Wing of ♂: *a*, *Thyridanthrax lineus*, Lw.; *b*, *Th. beneficus*, sp. n.

ing approximately proximal two-thirds of fore border, hyaline; veins, including costa, dark mummy-brown; apical dip in second longitudinal vein often fairly deep, and vein distinctly bent forward in front of it; costal cells and subcostal cell, latter only as far as end of auxiliary vein, mummy-brown; a small semi-hyaline spot usually distinguishable in infuscated area at extreme base of marginal cell, just before origin of second longitudinal vein; a similar semi-hyaline spot just below foregoing spot, at tip of first basal cell; first basal cell otherwise entirely dark mummy-brown; rather less, or rather more than proximal half of second basal cell infuscated (mummy-brown); upper margin, broadening out somewhat in upper distal angle, of second basal cell also narrowly infuscated; *anterior transverse vein unusually close to base of discal cell*, and, like extreme base of second longitudinal vein, narrowly edged on its proximal side with deeper infuscation. *Halteres*: knobs cream-coloured, stalks isabella-coloured. *Legs*, as also bristles on middle and posterior pairs, black.*

* Owing to the condition of the available material, it is impossible to describe *Th. beneficus* quite as fully as could be wished; it is hoped, however, that the details given above, in conjunction with the figures, will be sufficient to place the identity of the species beyond doubt.

PORTUGUESE EAST AFRICA: Kanyezi, Mossurise district, 5.xi.1918 (*C. F. M. Swynnerton*). Holotype ♂ and two ♂ paratypes bred from pupae of *Glossina morsitans*, Westw., found on granite-gneiss, alt. *circa* 600 ft., 31.vii.1918. Presented by the Imperial Bureau of Entomology.

A puparium of the present species, belonging either to the type or to one of the paratypes, measures 6·5 mm. in length, by 2·6 mm. in greatest depth dorso-ventrally; unfortunately, since the underside of the head-capsule and the proboscis-sheath are missing, nothing can be said as to the chitinous teeth.

# SOME METHODS OF TECHNIQUE APPLICABLE TO ENTOMOLOGY.

By A. D. Imms, D.Sc., F.R.S.,

*Rothamsted Experimental Station, Harpenden.*

The following methods of technique, along with many others, applicable to entomological work have been used by the writer in the course of a number of years' experience. Since a considerable proportion of the methods does not appear to be generally known, it is thought that the present article may prove of value particularly to investigators located in parts of the Empire overseas.

## *Mounting Media.*

*De Faure's Fluid.*—This is one of the most valuable of all mounting media for microscopical purposes, where small and delicate objects are involved. Its composition, as used by me for a number of years, is as follows :—

| | |
|---|---|
| Gum arabic ... ... ... ... ... | 30 gr. |
| Chloral hydrate ... ... ... ... ... | 50 gr. |
| Glycerine ... ... ... ... ... ... | 20 cc. |
| Dist. water ... ... ... ... ... ... | 50 cc. |
| Chlorhydrate of cocaine ... ... ... ... | 0·5 gr. |

After mixing these ingredients filter.

The medium has the advantage of killing, fixing and mounting in a single operation without the necessity for any previous or subsequent treatment. By virtue of the cocaine present it has the property of fixing whole organisms in an extended condition and is especially valuable for mounting endoparasitic Hymenopterous and Dipterous larvae, Protura, Coccidae and their nymphs, Mymaridae, Thysanoptera, Aleurodidae, certain Aphididae, eggs, etc. In fact almost any organism liable to shrink and distort by other methods, or rendered too transparent in Canada balsam, can, as a general rule, be better displayed in this medium. It is not claimed that uniform success will be achieved in every case, and the user must expect disappointing results in some instances. It is often advisable, but not absolutely necessary, to transfer the larger and less fragile organisms into a small quantity of the medium contained in a watch glass for a few hours before finally transferring to a spot of the fresh fluid on a slide. A few hours after mounting, an object, such as a Dipterous larva, will exhibit its tracheal system with remarkable clarity, showing up even the finer branches with great distinctness. As time goes on, the air gradually disappears from the tracheae, but it is often several months before it departs from the larger trunks. Under English conditions it is not necessary to ring the preparation, and I have examples ten years old that are quite satisfactory ; all that is required is to proceed cautiously and lightly when cleaning the cover-glass. As the age of the preparation increases the object becomes more transparent and in some cases very slight distension occurs. Objects such as Dipterous larvae tend to become yellowish brown in colour, but such morphological features as the spiracles, mouth-parts and oral papillae lend themselves to high-power examination. In moist, tropical conditions, where there is relatively little evaporation of the water present in the medium, ringing is desirable either by means of gold size or any other usual method. Experience, however, will soon determine the extent to which this procedure may be necessary.

*Berlese's Fluid.*—This medium, which was extensively used by the late Prof. Antonio Berlese for the permanent mounting of his great collection of Acarines, has the following composition :—

| | |
|---|---|
| Distilled water ... ... ... ... ... | 20 cc. |
| Chloral hydrate ... ... ... ... ... | 160 gr. |
| Gum arabic ... ... ... ... ... | 15 gr. |
| Glucose syrup ... ... ... ... ... | 10 gr. |
| Acetic acid ... ... ... .... ... | 5 gr. |

This medium has very similar properties to de Faure's fluid, in that it kills and fixes an organism in an extended condition. Living specimens may, therefore, be placed directly into the medium on the slide. When desirable they can be killed first by brief immersion in 10 per cent. acetic acid in distilled water or by being placed in boiling water. If, on the other hand, specimens are already preserved in alcohol they should be washed in 10 per cent. acetic acid before transference to the medium. In all cases, after the cover-glass has been put on, the slide should be gently warmed (not allowed to boil) for a short time, then allowed to cool and afterwards left for one or two weeks to dry and set. Finally it is desirable to ring the preparation with gold size or asphalt varnish (obtainable from opticians).

My former colleague, Dr. J. Davidson, who has used this medium extensively for mounting Aphids considers that it is better adapted for the majority of these insects than de Faure's fluid.

*Gilson's Euparal.**—This is a mixture of camsal, eucalyptol, paraldehyde and sandarac ; it exists in two forms, the green and the colourless, the latter I consider is to be preferred.

The value of this medium, its superiority to Canada balsam in many cases, and the brevity of the previous treatment required, merit a more general use than is accorded it at the present time. Objects, stained or unstained, after killing and fixation, are passed through graded strengths of ethyl alcohol in the usual way. After transference to 95 per cent. alcohol, they can be placed direct in euparal on the slide and the cover-glass superimposed. The use of absolute alcohol and a clearing agent are thus dispensed with which is a great advantage, especially for workers away from centres of civilisation. The transference from 95 per cent. alcohol to a preparatory agent termed " essence d'euparal " is advocated, but in my experience I have never found this necessary. It is even possible to transfer thin objects, such as preparations of chitinous cuticle, direct from 70 per cent. alcohol to euparal. The latter medium sets hard like Canada balsam but, unlike the latter, does not turn yellow and discolour with age. Preparations made twelve years ago are still as colourless as the slides upon which they are mounted. Its refractive index ($n=1{\cdot}483$) is lower than that of Canada balsam ($n=1{\cdot}524$), and for this reason it is also especially valuable for objects which are rendered too transparent by the latter medium. It can be used for all objects which, in the usual way, would be mounted in balsam.

### *Celluloid Mounting.*

It is incumbent in describing small insects to make microscopical preparations of the male genitalia, mouth-parts, and other structural features. A method which I have used with success is to procure sheets of celluloid, about the thickness of thin Bristol board, or thinner if required for minute, flat objects. Such sheets are cut up into strips of uniform size and slightly beyond the middle a circular hole is made either with a steel punch or a cork-borer.† A set of the latter tools is useful in that it allows of holes of different sizes to be made according to the dimensions of the objects.

* Obtainable from Messrs. Flatters and Garnett Ltd., 309, Oxford Road, Manchester.

† Suitable punches such as are used for cutting out card discs for mounting small Diptera are obtainable from Messrs. Watkins and Doncaster, 36, Strand, London, W.C.2. Sets of cork-borers can be procured from any dealer in laboratory apparatus.

On the lower side of the hole thus made, a circular cover-glass, of slightly longer diameter, is sealed in position by means of Canada balsam or euparal and allowed to dry. The object is then mounted in any of the media already described and a cover-glass placed over it. An adhesive label is not necessary as the required data can be written on the celluloid with a fine pen and waterproof Indian ink; when dry, permanency can be secured by painting over the written data with the thinest possible coating of euparal or balsam. In order to ensure neatness it is best to use very fluid xylol balsam and apply it with a fine brush. Finally a pin is inserted through the celluloid below the data as with an ordinary carded specimen.

The advantage of this method is that the object can be pinned in its proper place in an ordinary collection of dried insects. Or, a whole collection of such insects as Anoplura, Aphaniptera, larvae, etc., can be mounted in this manner, each species being placed in its correct taxonomic position in cabinet drawers or store boxes. A collection or an individual object, mounted in this manner, is readily available for microscopical examination ; when high powers of the microscope are desired, all that is necessary is to withdraw the pin, and the whole preparation then becomes comparable with an ordinary micro slide. The most convenient size of the celluloid slips is about 2 ins. by 1 in. but larger or smaller dimensions can be adopted of course if desired in conformity with the size of the object.

*Staining.*

*Fuchsin.*—In the present article I am only dealing with the staining of those chitinous structures which are too transparent when mounted in an unstained condition to be readily studied with accuracy. Under this category come the wings of many minute parasitic Hymenoptera ; the wings of the smaller Diptera, especially those with the venation ill-defined, or with obscurely discernable vestigial veins ; the pores and gland openings on the pygidium and other regions of Coccidae ; the mouth-parts, spiracles, etc., of minute larvae ; in fact any transparent delicate part or organ whose structure is difficult to discern by ordinary procedure. The advantages derived from the proper staining of such structures are evident from the facility with which they can be studied and the consequent relief from undue eye-strain, the accuracy with which they can be drawn and measured, and the elimination of the possibility of the less defined structures being inaccurately interpreted.

The stain most generally used and recommended is fuchsin, and ordinary fuchsin or magenta is a basic dye and is the hydrochloride of rosanilin. Acid fuchsin is the sodium salt of a sulphonic acid derived from fuchsin. Both acid and basic fuchsin are used as chitin stains, but in my experience basic fuchsin gives the better results. In the form known as Ziehl's carbol-fuchsin it is extremely effective and is usually made up by taking 10 cc. of a saturated solution of basic fuchsin in 95 per cent. alcohol and 100 cc. of a 5 per cent. solution of carbolic acid in distilled water. The two are then shaken together and the stain is ready for use. For delicate and refined technique the emended formula given in McClung's Microscopical Technique, 1929, may be used, viz. :—

Solution I.

| | | |
|---|---|---|
| Basic fuchsin (90 per cent. dye content) | ... | 0·3 grms. |
| Ethyl alcohol (95 per cent. strength) | ... | 10 cc. |

Solution II.

| | | |
|---|---|---|
| Carbolic acid | ... | 5 grms. |
| Distilled water | ... | 95 cc. |

Solutions I and II are then mixed for use.

Material is transferred to the stain and left there as long as may be necessary; if very rapid staining is required, slightly warming the stain containing the object in a watch-glass will accelerate its action. On the other hand, if an object be left for 14 hours or more in the stain no harm will ensue, and decolorisation to the appropriate degree may be achieved by transference to 95 per cent. alcohol containing 3 per cent. by volume of concentrated hydrochloric acid. It is always desirable to leave the specimens slightly darker stained than is necessary as a certain amount of subsequent decolorisation occurs. If mounting is done in Canada balsam, clearing should be by means of carbol-xylol, and the balsam, it may be added, should be xylol balsam.

A simpler stain is obtained by taking 1 grm. of basic fuchsin (magenta crystals) and dissolving it in 100 cc. of 95 per cent. alcohol, as has been recently advocated by Ferris.* Any excess of the stain can be removed by washing in 95 per cent. alcohol; this should be done as quickly as possible under a microscope or too much loss of colour results.

### *Decolorising Chitin, etc.*

It often happens that chitinous parts are too darkly coloured to admit of the clear definition of structural details. This disadvantage may be overcome by taking a small stoppered phial and covering the bottom with a few drops of concentrated hydrochloric acid diluted by half its bulk of distilled water. Add a few crystals of potassium chlorate and very soon the greenish-yellow fumes of chlorine become evident in the phial. The part to be decolorised should be immersed quickly in the liquid and left there until it becomes paler in colour. After removal and momentarily washing in dilute alcohol it is ready for mounting. Specimens covered with thick black chitin are difficult to bleach, and several days' treatment are usually necessary. Very delicate objects that will not withstand the acid can be suspended on a piece of moist filter paper in the phial so as to come into direct contact with the chlorine vapour only.

In the case of Collembola and other insects in which structural details are often concealed by a heavy deposit of dark hypodermal pigment, decolorisation can be effected by treatment with 10 per cent. potassium hydroxide and afterwards washing in distilled water.

### *Dissecting Fluids.*

For the dissection and examination of minute delicate objects, including polyembryonic phases, glands, blood cells, oenocytes, fat-body, parasitic micro-organisms, etc., in the living condition, normal salt solution often causes rupture or distortion of the parts or cells it is desired to examine. The insect is best opened in Ringer's solution whose composition is as follows :—

| | |
|---|---|
| Sodium chloride ... ... ... ... ... | 0·8 grm. |
| Calcium chloride ... ... ... ... ... | 0·02 grm. |
| Potassium chloride ... ... ... ... | 0·04 grm. |
| Sodium bicarbonate ... ... ... ... | 0·02 grm. |
| Distilled water ... ... ... ... ... | 100 cc. |

As an alternative, and much quicker to make up, Pictet's liquid, which is a 1 per cent. to 3 per cent. solution of manganese chloride, is recommended by Bolles Lee.†

### *Preserving Fluids.*

*Alcohol.*—For ordinary purposes ethyl alcohol is in general use. The strength

* Principles of Systematic Entomology, Stanford Univ. Publications Biol. Sciences, v, no. 3, 1928.

† Microtomist's Vade-Mecum.

commonly adopted is 70 per cent. but in many cases this results in course of time in maceration supervening. I prefer 80 per cent. alcohol to which five parts by volume of glycerine have been added. With larvae and pupae, shrinkage and often distortion result if placed in the alcohol straight away. These disadvantages can be greatly reduced, or almost eliminated, if the specimens are first placed in 40 per cent. alcohol which is gradually warmed up to the boiling point. On allowing to cool down they should be transferred to 70 per cent. alcohol and finally to 80 per cent. strength.

Specimens so treated are usually sufficiently well preserved for subsequent study or descriptive purposes.

*Pampel's Fluid.*—This is useful for keeping material for a length of time with the tissues in a soft flexible condition for subsequent dissection. After chloroforming the insect a small slit is made along the side of the abdomen to allow of ready penetration by the preservative fluid. It was first used by Pampel* and later by Miss L. Florence† in her studies on the Hog Louse and by other workers. It is particularly useful in cases where, for example, important characters are afforded by the genital organs and where dissection cannot be made straight away. Its composition is as follows :—

| | |
|---|---|
| Glacial acetic acid ... ... ... ... | 4 parts. |
| Distilled water ... ... ... ... ... | 30 parts. |
| Formaldehyde ... ... ... ... ... | 6 parts. |
| 95 per cent. alcohol ... ... ... ... | 15 parts. |

*Lavdowsky's Solution.*—This method is very simple and practical and is best adapted for large objects such as Lepidopterous larvae, where rapid penetration takes place with greater facility than in very small organisms. The method has been slightly modified by Tothill‡ whose recommendations I have found to be of great value. Place the insect, or part of an insect, in 5 per cent. chloral hydrate in distilled water and gently warm for a minute or so until the temperature does not quite reach boiling point. The object is then left on a piece of filter paper for about five minutes, until the fluid has drained away. It is then transferred to a bottle of fresh chloral hydrate of the same strength and is left therein for one week. It is removed and drained a second time, and afterwards submerged in further chloral hydrate. The bottle is then tightly corked, and the specimen will keep for several years in a condition fit for dissection. The complete penetration of the chloral hydrate is ensured by making a slit along one side of the insect with a surgeon's needle or other suitable instrument.

### *Storage of Spirit Material.*

One of the greatest difficulties in the storage of valuable spirit material in small phials is the ultimate shrinkage and deterioration of the corks. This results in evaporation of the alcohol and the necessity for frequent examination of such a collection to avoid the specimens drying up altogether. This disadvantage may be obviated in one of two ways.

The specimens can be transferred to phials of alcohol in the usual way and the mouth of each phial closed either with a piece of fine muslin tied securely round with cotton, or loosely plugged with cotton wool. The phials are then inverted in a straight-sided stoppered museum jar previously filled with alcohol. Specimens thus taken care of remain a long time without attention and all that is necessary is to add

* Pampel, W. 1914. Die Weiblichen Geschlechtsorgane der Ichneumoniden.—Zeits. für wiss. Zool., 108, pp. 290–357.

† Florence, L. 1921. The Hog Louse, *Haematopinus suis*, Linné.—Memoir 51, Cornell Univ. Agric. Expt. Station.

‡ Tothill, J. D. 1919. The Chloral Hydrate Method of Preserving Insects for Dissection.—Proc. Nova Scotia Ent. Soc. (I am indebted to Dr. J. W. Munro for this reference.)

occasionally to the alcohol that evaporates in the jars. It is, of course, easy by this arrangement, to keep a number of species of a genus each in its own phial in a single jar.

Or the use of phials may be dispensed with and each specimen enclosed in a short length of glass tubing whose bottom had been previously sealed in a Bunsen burner. The tube is partly filled with 80 per cent. alcohol and the specimen introduced. Nearly all the alcohol is then poured off and the tube drawn out to a point, at some distance from the object, by means of a Bunsen flame. After breaking it off at the neck it is then filled with alcohol by means of a fine tubular funnel. The broken off end is then sealed in the flame and the process finished. Care and practice are required to carry out the operation neatly and it is important to ensure that the broken off neck is as small as is practicable, so as to admit of rapid sealing in a hot flame. A label is best introduced into the tube along with the specimen. I first came across this method in 1905 when examining the Haviland collection of termites at Cambridge which are preserved in sealed up lengths of tubing. The earliest published suggestion I know of is a note by Nachtrier,* who also recommends equal parts of alcohol, glycerine and water (Fleming's fluid) in place of pure alcohol.

### *Methods of Rearing Insects.*

*Iron Rings as Covering Frames.*—A number of years ago Mr. E. E. Green recommended to me the use of heavy iron rings covered with muslin for closing circular breeding vessels. This very simple device dispenses with the time taken in securing pieces of muslin by means of string or rubber bands each time the receptacles are opened. The rings require to be made slightly larger than the diameter of the receptacles to be used, and since their weight exerts a tension on the muslin, the insects are precluded from escaping. A stock of such rings of different sizes can be readily made by a blacksmith, at small cost, from iron rods of varying diameter (according to the weight needed).† In order to prevent rusting they can be painted with aluminium paint or other preservative before the muslin is sewn on. A quicker method is to cut out circles of muslin of the required diameter and fasten them to the rings with marine glue.

*Petri Dishes.*—For a number of years past I have adopted ordinary double Petri dishes as used by bacteriologists for plating cultures. The advantage of this method is the ease with which they can be kept sterile while the contained insects can be readily observed under a binocular microscope. Various kinds of small insects can be reared in these receptacles, and for studying many of the parasitic Hymenoptera, for example, they are invaluable, because the behaviour of such parasites in relation to their hosts can be clearly watched. A suitable-sized Petri dish is about 9 cm. diameter and 1·5 cm. in height (inside dimensions) for the lower dish, and it should be stipulated when purchasing that the edge of the lower dish is ground perfectly flat so that the inverted upper dish reposes accurately upon it ; this precaution is necessary or minute insects would be liable to escape. If desired, the upper or covering dish can be replaced by one of the heavy iron muslin-covered rings already alluded to.

*General Rearing Cage.*—An inexpensive type, which admits both light and air and at the same time allows of free observation, can be quickly put together as follows. A hurricane lamp chimney of as wide a mouth as possible is fitted over an ordinary plant pot of suitable size, and the upper opening of the lamp chimney is closed with one of the muslin-covered rings already mentioned. The plant pot serves to hold a phial containing water to keep the food-plant fresh, and the space between the phial and the pot may be filled with fine soil or sand. Where soil is not needed, as with Hemiptera,

* Nachtrier, H. F. Journal Royal Microsc. Soc., 1900.

† A very convenient size is 6 ins. outside diameter, made from rod *not less* than 1 in. in circumference.

the lower opening of the lamp chimney can be closed with a cork bung perforated to allow of the stems of the food-plant being placed in the water below. Most kinds of plant-feeding insects can be reared in cages of this type, and the ease with which the latter can be kept clean is greatly in their favour.

*Receptacles for Soil Insects.*—Subterranean insects are often notoriously difficult to rear, owing to the fact that once soil is placed in a pot or other receptacle, physical changes supervene which render it difficult to maintain natural conditions. Wireworms, Melolonthoid larvae, and other true soil insects can be reared successfully if the pots containing the soil are let down into the ground to within about an inch of their rims. The pots must be unglazed and when placed *in situ* the moisture content and temperature are maintained in a condition approaching that of the surrounding soil. The pots require to be suitably covered and the nature of the covering naturally depends upon whether they contain growing plants or not. The opening at the bottom of the pot requires to be enlarged to admit of free drainage and closed with gauze or perforated zinc. If such receptacles are not freely exposed to the weather, or periodical watering is necessary, a very small sized earthen pot, inserted almost flush with the surface of the soil, in the centre of the larger pot, is desirable. This small pot can be filled with a uniform amount of water in the case of critical experiments, but its main use is to prevent the soil from caking at the surface, which almost invariably happens if water be applied in the usual manner. With some insects, such as wireworms, chafer larvae, etc., which at certain times of the year penetrate deeply into the soil, unglazed drain pipes are often better than plant pots. The taller vessels allow of the free migration of the insects through a great vertical distance in the soil.

# A NEW PEST OF RICE IN SOUTH INDIA.

By P. N. Krishna Ayyar, B.A.,

*Madras Agricultural Department.*

In July, 1926, a severe outbreak of a Hemipterous pest was reported from the village of Kattuputhur, in the Trichinopoly District, which threatened the total destruction of the standing paddy crop, and the writer was deputed to visit the locality, investigate the pest and advise suitable control measures. The present paper has been prepared with the object of presenting the results of the investigation made and the remedial measures tried.

The village of Kattuputhur is situated about three miles from Kattalai Railway Station and a mile and a half from the Cauvery River. The affected area is roughly about ten miles long with an average breadth of a mile and a half, and includes numerous villages around Kattuputhur. It is adjoined by a canal from the River Cauvery, giving a never-failing and plentiful supply of water, so that the crops of the area are no longer dependent on the monsoon. As the soil is fertile, intensive cultivation is carried on within this tract, paddy being the principal crop.

## Local Agricultural Practices.

Generally there are two crops raised during a year—a short-duration crop locally known as " kuruvai," followed by " samba," a long-duration variety. The former covers a period of three and a half to four months, being raised generally between March and June, and the latter nearly six months, between August and January ; consequently there is a well defined break of nearly two months between consecutive crops when there is no crop on the land.

During the past few years this system would appear to have been modified to some extent by the ryots of the locality in their desire to utilise fully the unfailing supply of water. Accordingly they have begun to raise five crops (three kuruvais and two sambas) during a period of two years. They raise a kuruvai from March to June and a second kuruvai from June to September, then a samba from September to February followed by a kuruvai and a samba during the second year. Thus the crops come in quick succession one on the heels of the other within two years. It is clear from this that the usual dead season of two months between successive crops has been cut out to a very large extent.

## Character and Extent of the Outbreak.

The insect under review was usually considered a minor and unimportant pest of paddy, and this is the first time that it has been reported to occur in such destructive numbers. Thousands of bugs, mostly adults, were seen on the paddy fields of the locality. The infested crop was only a month and a half old, being kuruvai of a hundred and five days' duration. This crop is generally broadcasted, but small areas had also been transplanted, and both had been attacked and destroyed by the bug. The sudden devastation of a large number of fields naturally excited no small alarm among the cultivators, as even the oldest ryots of the locality had never before experienced such a severe outbreak of the bugs.

The fields presented a characteristic yellowish brown, dried-up appearance, and although the crop was very young it looked from a distance as if it were ready for harvest. There were some fields in the neighbourhood that were only just beginning to receive the attentions of the pest, and here the gradual process of destruction could be easily made out in its different stages. The first affected portions of the plant are

the outer leaf-sheaths, which turn yellow, and the plant makes little or no growth. Soon the inner leaves also turn yellow and dry up, until at last the plant dies. When the plants in an area have thus been sucked dry, the bugs begin to fly in quest of fresh green fields.

## Species of Insects Concerned.

The insects responsible for the damage are bugs belonging to the family PENTATOMIDAE, *Tetroda histeroides*, Fabr. (subfamily PHYLLOCEPHALINAE) and *Scotinophara lurida*, Burm. (subfamily GRAPHOSOMATINAE). The former is known locally as "nama-vandu," owing to the presence of a V-shaped mark on its back resembling the "namam" or caste-mark of the Vaishnavaite sect, and the other goes by the name of "karivandu" because of its dark colouration. The latter (*Scotinophara*) was, however, only of minor importance, being present in much smaller numbers than *Tetroda*, which was the main agent concerned in the present outbreak.

In the attacked area each plant, or rather each bunch of plants, harboured on the average about 15 to 20 bugs of the former species and a few (about one to four) of the latter. The upper part of the base of each bunch of plants was occupied by the larger bugs and the lower portions by the smaller ones, and the bugs migrated upwards with the rise of the water-level in the fields.

The more experienced ryots of the locality were not unfamiliar with these insects. They had considered them harmless creatures and had never associated them with the present type of devastation. During the previous year the bugs had slightly increased in numbers and threatened to cause some injury, but the loss was inconsiderable. But when several acres of paddy crops were completely sucked dry and a total failure of crops stared them in the face, the ryots were taken absolutely by surprise.

## Alternative Host-Plants and Distribution.

A careful search in the area and the neighbourhood did not reveal any alternative host-plants. Although a few bugs were seen temporarily resting on sugar-cane and plantain leaves in gardens adjoining paddy crops just harvested, they were never observed to breed on these; nor were they found breeding on grasses. Hence it is very probable that they breed only on paddy, and since this food-plant is available throughout the year in some part or other of the locality, owing to the changed system of cultivation, the abnormal increase in the numbers of the insects can be easily accounted for.

This bug has a wide distribution in South India, though in the Coimbatore collection the species is represented by specimens collected only from the following districts: Salem, Malabar, Coimbatore, Trichy and Chittoor. It has been recorded almost in all cases on paddy, with the exception of certain specimens collected from jak shoots (*Artocarpus integrifolia*) in Malabar.

## Oviposition.

Generally the eggs are laid some time after mating, but in one case oviposition was observed within five minutes. They are usually laid on the lower surface of the overhanging distal halves of the lowest leaves, but rarely also in the upper sides. They are deposited in batches containing 4 to 31 eggs, the number most usually met with being 14. The largest total number of eggs obtained from a single female did not exceed 31. The eggs are invariably laid in two contiguous rows.

**Early Stages.**

*The Egg.*—This is somewhat cylindrical, being 1·2 mm. high and 0·9 mm. in diameter. The distal end is flat and carries a circular lid or operculum, which has a dentate edge, the dorsal margin of the egg being also toothed. When freshly laid, the eggs are greenish in colour, but become paler later. On the fourth day a pair of

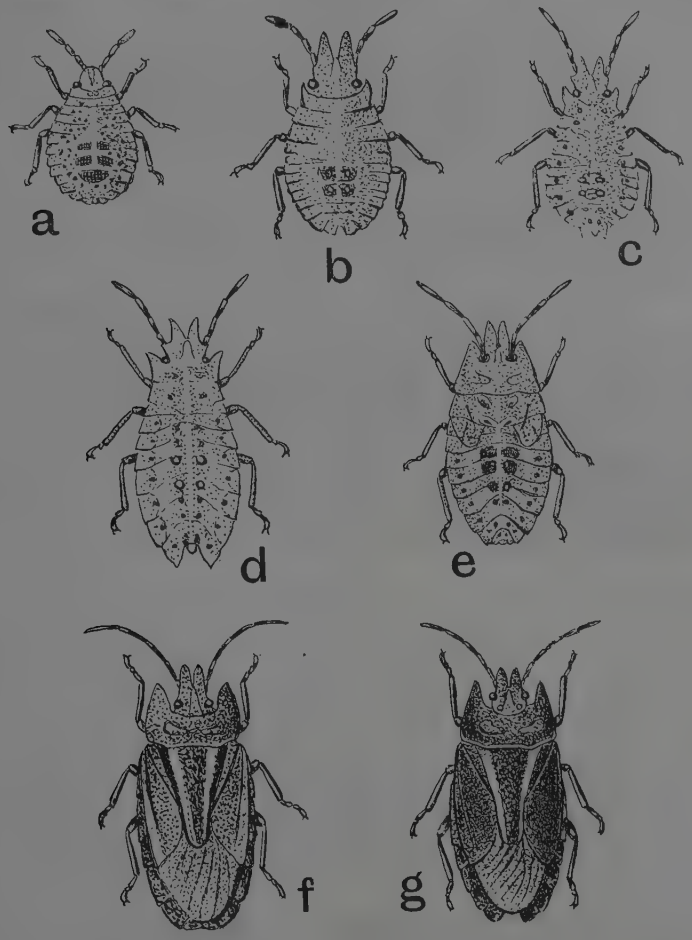



Fig. 1. *Tetroda histeroides*, F.: *a*, nymph of 1st instar, ×15; *b*, 2nd instar, ×7·5; *c*, 3rd instar, ×3·75; *d*, 4th instar, ×3·75; *e*, 5th instar, ×2·5; *f*, adult ♀, ×2·5; *g*, adult ♂, ×2·5.

crescent-shaped pinkish marks, representing the eyes of the developing nymph, are visible through the transparent cap. Near the developing head there is a membranous triangular structure with a T-shaped chitinous thickened rib, which projects slightly; probably this structure functions as a lever for pushing open the operculum. On the sixth day the egg becomes whitish in colour and is about to hatch. While hatching,

the nymph pushes the cap on one side and emerges slowly, taking a few minutes for the operation. The lid opens like a door on its hinges and remains ajar, but in a few cases it drops off. The egg stage lasts 5–7 days, with an average of 6·3 days.

*First Nymphal Instar* (fig. 1, *a*).—The nymphs, on hatching, do not travel far, but arrange themselves in two rows along the blade of the leaf close to the empty shells and remain quiescent for nearly two days, apparently without feeding. They are pyriform and whitish in colour; the dorsum bears four dark blotches, which are probably the rudiments of the stink glands; on the disk of the abdomen on either side of the mid-dorsal line are some pinkish dots that form indefinite patches; the abdominal border is whitish, with dusky spots bearing short setae, the lateral margin being serrate; head and thorax whitish, usually with a few dusky dots; venter pearly white; legs dark, except the femora; rostrum creamy white, with the tip brownish. Length 1·5 mm.; width 1·3 mm. After a period of four to five days, the nymph undergoes its first moult.

*Second Nymphal Instar* (fig. 1, *b*).—During the second instar the nymph becomes flatter and more oval. The general colour is dirty white, with the head and thorax darker and the dark blotches on the abdomen more pronounced, the whole surface bearing indefinite red dots. It measures 3·7 mm. in length, the greatest width being 2·5 mm. The head lobes about 0·2 mm.; eyes dark and distinct; antennae about 1·7 mm. long. Antennae and legs dark except on the basal joints, which gradually become darker distally. The rostrum creamy white, except at the tip, and extending as far as the 1st coxae. The anterior prothoracic angles projecting forwards, about 0·4 mm.; the lateral margins of the thorax and abdomen serrate. This instar is perhaps the longest, varying from 8 to 20 days, with an average of 13 days.

*Third Nymphal Instar* (fig. 1, *c*).—The nymph in this stage assumes an elongate form. Length 6·5—7·0 mm., width 4·5 mm.; head lobes 0·7 mm.; antennae 2·2 mm.; prothoracic processes 0·5 mm. long. The general colour is still dirty white, with the legs and antennae dark. Thorax less transparent than the abdomen; abdominal segments more distinct. This stage lasts on an average 9 days, varying from 7 to 15 days.

*Fourth Nymphal Instar* (fig. 1, *d*).—Length 8·5 mm.; width 5·5 mm.; head lobes 1·5 mm.; antennae 4 mm. long., creamy white with a pinkish tip; prothoracic processes 0·9 mm. The scutellum has begun to be distinguishable; wing-pads just visible and covering one segment of the abdomen. Legs whitish, except at tips of the joints, where they are dark. Abdominal segments distinct. This stage lasts for 9·6 days on the average, ranging between 7 and 20 days.

*Fifth Nymphal Instar* (fig. 1, *e*).—Length 13·6 mm.; width 7·8 mm.; head lobes 2 mm.; antennae 4·6 mm.; prothoracic processes 1 mm. The general colour is dirty white, the head and thorax having assumed a still darker shade; proboscis creamy white. Scutellum and wing-pads distinct and more prominent, the latter extending as far as the middle of the 3rd segment of the abdomen and the former only up to the 2nd segment. This stage lasts about 11·6 days on the average, ranging between 9 and 15 days.

The final moult occupies only a few minutes, the epidermis splitting along the top of head and then over the thorax and abdomen. The newly emerged adult is soft and almost white, but the normal colours appear in a few minutes. It was not possible to estimate correctly the proportion of males and females in the field during the outbreak. In the laboratory out of 16 individuals, the sex of which was noted on emergence, it was found that there were 7 females and 9 males, making a percentage of 44 and 56.

The nymphs were not very active at any stage and were usually found to rest on the lower surface of tender leaves. When disturbed they drop to the ground, and sometimes they were seen to eject a white liquid from the posterior end. The total

period from the laying of the egg to the emergence of the adult varied from 49 to 62 days, the average time being 56·4 days for 17 individuals, and the adults are capable of living for at least two months under laboratory conditions, but may live longer in nature.

## Natural Enemies.

The only natural enemies observed were two egg parasites. One of these is a small dark Chalcid, possibly *Anastatus colemani*, and the other possibly a Braconid.

Attempts were made at the Insectary to rear the parasites under laboratory conditions and study the possibilities of multiplying them in cages for purposes of liberation in affected areas. The wasps fed freely on sugar solution and oviposited in fresh eggs of *Tetroda* provided for them. The development of the Braconid parasite took 15 days in all cases, whereas that of the Chalcid in three cases was only 8 days and in the rest 12–13 days. The Chalcids, in addition to being more numerous, were found to be the hardier of the two, and the possibility of breeding them in numbers under laboratory conditions is certainly greater.

## Control Measures.

The pest has never been hitherto sufficiently destructive to make treatment necessary. This outbreak has, however, brought into prominence its economic importance, both actual and potential. Notwithstanding the handicap in tackling a new pest in respect of which no previous information was available, a few methods to check its ravages were tested.

Hand-picking was tried and was certainly very effective in the area treated, but as the cleared areas very soon became re-infested by the bugs coming in from neighbouring fields, this method did not find favour with the ryots. The pest being so widespread, hand-picking will be impracticable, unless there is whole-hearted co-operation among the ryots of the locality, and this was far from being the case.

Hand-netting was tried but with little success, as the bugs were not easily detached from the plant except when it had been sucked dry.

Light traps were put up in various parts in the area, but the bugs were not attracted to any great extent.

Calcium cyanide (A) dust was tried with a Cyanogas dusting machine, but proved to be of little use. Spraying " Flit " with a hand-sprayer was also tried but was found to be ineffective.

Another method resorted to was to let in numerous ducks, which were available in thousands in these parts, as a means of clearing the fields of bugs, after flooding. The ducks were seen to pick up the bugs with great avidity, but produced little effect; as the number of insects eaten was insignificant as compared with those still left. It was feared also that if tried repeatedly the ducks would do more harm to the crop than the bugs themselves.

Spraying with crude oil emulsion and kerosene with water, in the proportion of 1 to 10 in the case of the former and 1 to 20 in the latter, proved more effective and can be recommended for further trial.

As plenty of water was available, sweeping the bugs after flooding the field was found to be the most satisfactory method in the circumstances. As water was let in and the level gradually rose, the bugs slowly crawled up the plants. At this stage bamboos and ropes were dragged over the fields so as to knock the bugs down. But this was soon found to be unsatisfactory, because the insects so dislodged swam clumsily to other plants near by. Enough water could not be let in so as to submerge the plants completely, as the bunds were small and low. Therefore, later on, women

coolies were employed to sweep away the bugs with brooms and collect them in a corner of the field to be ultimately destroyed by immersion in kerosene and water. The cost entailed in this process is inconsiderable, as half a dozen women coolies were found to be capable of clearing numbers of fields effectively in one day. This measure soon gained popularity among the cultivators and was practised extensively. The essential condition of success in this method is co-operation among the ryots; otherwise the negligence or indifference of any single refractory ryot is likely to mar the efficacy of the labours of all the rest.

**The Outbreak and its Significance.**

The study of this outbreak proves that the really important factor responsible for bringing about a sudden increase of *Tetroda histeroides* was the recent change in the scheme of paddy cultivation in the area affected, which has ensured an abundant and continuous supply of food for the insect throughout the year. This bug has been known to the ryots of the locality for nearly ten years past, but had not previously been noted to commit any such devastations. As it has not been observed to breed on anything other than paddy, the slight increase of this pest during the previous year and its sudden multiplication in surprising numbers in the succeeding year are almost certainly due to the change in the system of cultivation introduced in recent years.

In conclusion, I wish to express my thanks to the Government Entomologist, Madras, for having afforded me the opportunity of studying this pest.

# CONFIRMATORY EVIDENCE OF THE VALIDITY OF THE SPECIES *PECTINOPHORA SCUTIGERA*, HOLDAWAY (QUEENSLAND PINK BOLLWORM), FROM A STUDY OF THE GENITALIA.

By F. G. Holdaway, Ph.D.,

*Entomologist, Council for Scientific and Industrial Research, Canberra, F. C. T., Australia.*

In a former paper on the pink bollworm of Queensland[3], the writer put forward evidence supporting the hypothesis that the Queensland pink bollworm was a new species and indigenous to Australia. The present paper gives confirmatory evidence from a study of the genitalia of the adults.

Lepidopterists to whom adults were submitted, considered them identical with *Pectinophora gossypiella*. However, evidence from the larvae and pupae and also from host-plant and distribution records indicated that the Queensland insect was distinct. The name *Pectinophora scutigera** was therefore proposed for it.

With such striking differences in the immature stages, it was felt that differences no doubt occurred in the adults also and further study would reveal them. The present paper records the differences found in the genitalia and confirms the original contention that the Queensland pink bollworm is a distinct species.

Before considering the genitalia it will perhaps be advantageous to review briefly the main points of the earlier paper.

In the mature larvae the most striking character distinguishing *P. scutigera* from *gossypiella* is the presence of definite chitinised plates or pinacula surrounding all the setae. In *gossypiella*, pinacula occur only on the prothorax, and these are but slightly chitinised. In addition, the crotchets on the prolegs in *scutigera* are arranged in two horizontal crescents, in contradistinction to the " horse-shoe " arrangement in *gossypiella*.†

The validity of this character has been criticised and the argument put forward that the crescents of the larvae under examination had resulted from the dropping out of a few of the crotchets from the inner closed portion of the " horse-shoe " arrangement, such as occurs in *gossypiella*. This criticism, however, is quite ungrounded. Examination of a large number of larvae indicates that the arrangement in crescents is a constant character. Moreover the mean number of crotchets in *scutigera* is even greater than that in *gossypiella*. In addition, a study of the crotchets in all the larval stages reveals the fact that the crescents have been evolved by a moving round of the crotchets from an outward position in the first instar to anterior and posterior positions respectively in subsequent instars ; in other words, the arrangement of the crotchets in crescents is due to a failure to form a " horse-shoe " rather than an origin from the " horse-shoe " (fig. 1).

Fig. 1. The arrangement of crotchets on the prolegs of the four larval stages of *Pectinophora scutigera*, illustrating the evolution of the " double crescents " (not drawn to scale).

* Recently the writer has expressed the opinion that Busck's genus *Pectinophora* rather than Meyrick's *Platyedra* is the genus to which *gossypiella* and *scutigera* should belong.[4] Formerly,[3] following Meyrick, the genus *Platyedra* had been adopted.

† Dr. W. T. M. Forbes informs me that differences of this nature are sometimes used for family differentiation in Lepidopterous larvae.

Further evidence supporting the individuality of the Queensland insect was obtained from the shape of the larval head. This was particularly well shown by a graph of the Epicranial Index[6] $\left(\frac{\text{Front}}{\text{Epicranial stem}}\right)$ of the heads of the larval stages of both species. Additional differences were found in the structure of the cuticle, and

Fig. 2. *Pectinophora scutigera*, ♂ genitalia, showing the relationship of the parts.

in the position of the various setae. Moreover in the pupae the setae surrounding the cremaster were found to lend further support to the belief that the Queensland pink bollworm was distinct.

Adults submitted to Mr. Edward Meyrick, of Great Britain, Mr. August Busck, of the U.S. National Museum, and Dr. A. Jeffries Turner, of Brisbane, were identified as *P. gossypiella*. It is thus apparent that external characters gave no indication of the insect's individuality. Feeling that the differences must be present, the writer directed his attention to the genitalia and found that in both sexes these organs showed conclusively that the Queensland insect was distinct from *P. gossypiella*.*

The genitalia of *P. gossypiella* have been figured by Busck[1]. Those of *P. scutigera* are similar in general form but differ in detail (fig. 2). Normally the claspers form with the tegumen and uncus a triangular-shaped tube surrounding the aedoeagus. They are here figured, spread out, to show their structure more clearly. The various parts in the two species are figured for comparison. The nomenclature is that used by Busck & Heinrich[2], which is practically identical with that originally put forward by Pierce.[5]

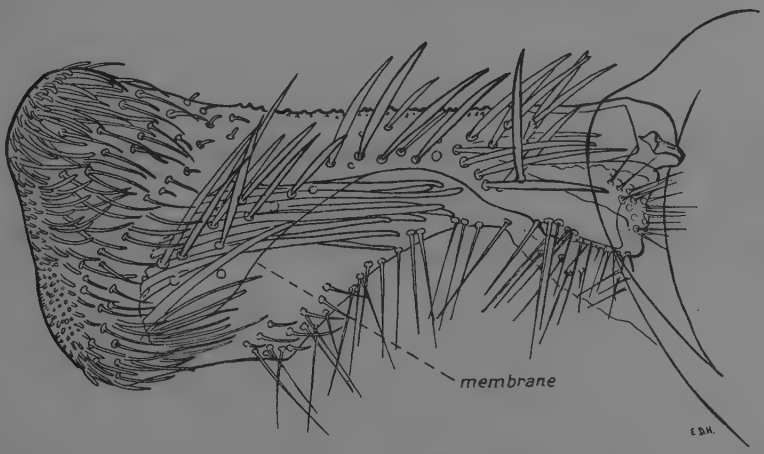



Fig. 3. Clasper of *Pectinophora gossypiella*.

The most striking differences, which can readily be seen from the accompanying figures, are as follows :—

1. The shape of the clasper is different in the two species. In *gossypiella* (fig. 3) the broad portion or valvula (posterior in life) is wider and more rectangular than in *scutigera* (fig. 4), and the dorsal edge is more strongly concave in the former than in the latter.

2. The position of the longitudinal bundle of setae on the clasper differs in the two species. In *scutigera* it occurs near the margin while in *gossypiella* it is more centrally placed and leaves the margin exposed.

3. The setae are longer and stouter in *gossypiella* than in *scutigera*. Moreover in the former they are fewer, numbering 12–16, whereas in *scutigera* they are more numerous and difficult to count.

4. In *gossypiella* a membrane covers the basal half (posterior) of the longitudinal

* This phase of the study was carried out in the Department of Entomology, Cornell University, during the tenure of a Research Studentship under the Science and Industry Endowment Act, Australian Council for Science and Industrial Research, and had the general supervision of Dr. O. A. Johannsen and Dr. W. T. M. Forbes, whose interest and encouragement are gratefully acknowledged.

bundle of setae. It bears stout setae similar in size and form to those occurring on the ventral portion of the clasper. In *scutigera* the longitudinal setae are free, there being only a slight indication at their base of the membrane which is so well developed

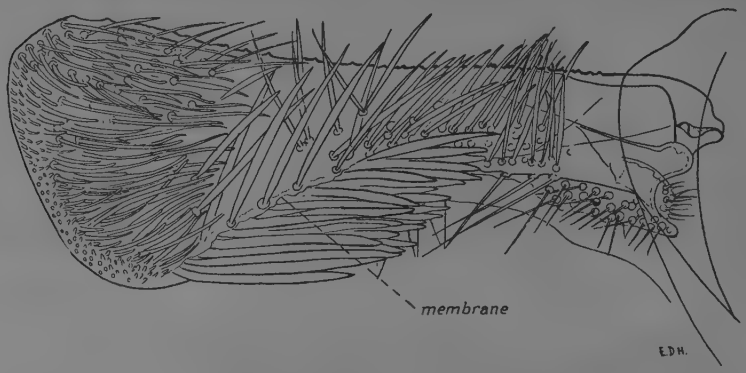



Fig. 4. Clasper of *Pectinophora scutigera*.

in *gossypiella*. (The membrane is very delicate, and careful focussing and adjustment of light is required for its detection. It is, however, a very definite and constant structure.)

5. The setae between the longitudinal bundle and the ventral margin are shorter and stouter in *gossypiella* than in *scutigera*, in which they are thin and almost hair-like.

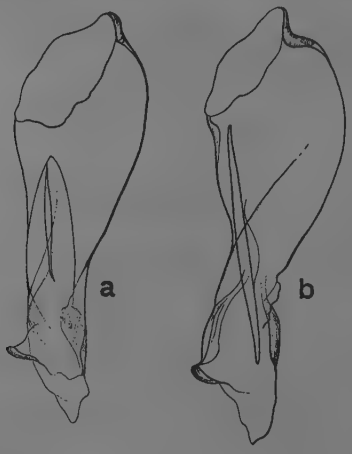



Fig. 5. The aedoeagus: *a*, *Pectinophora scutigera*; *b*, *P. gossypiella*.

6. In the aedoeagus (fig. 5) there is a spicule-like strengthening which is longer and stouter in *gossypiella* than in *scutigera*, while in the latter there is an additional finger-like area on which the spicule is borne.

7. The gnathos differs in the two species, as regards both the lateral and the fused central portions (figs. 6, 7).

8. In the female bursa copulatrix the signa (fig. 8) of *gossypiella* are very stout but slightly curved, while those of *scutigera* are less stout and strongly curved. In addition the teeth in *gossypiella* are confined to the marginal area whilst in *scutigera* they extend to the middle of the organ. Moreover the signa in the former species are toothed to the tip whereas those of the latter are not.

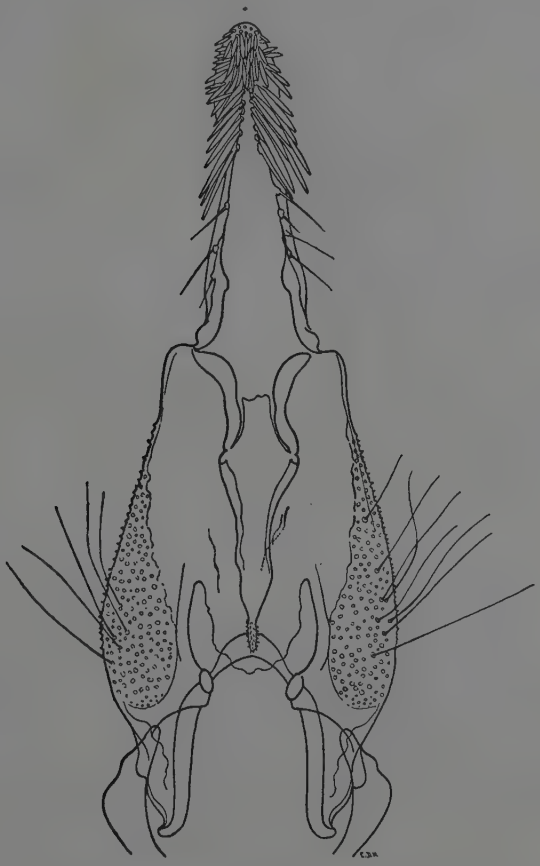


Fig. 6. *Pectinophora scutigera*, tegumen, gnathos, and uncus.

As mentioned previously, apart from the genitalia, characters have not yet been discovered in the adults by which *P. scutigera* may be distinguished from *P. gossypiella*. I have recently had an opportunity of examining a series of adults of the latter at the British Museum (Natural History) and comparing them with *P. scutigera*. They comprised specimens from Egypt, India and Hawaii. Those of *P. scutigera* were on the whole darker. However, with two species exhibiting such remarkable similarity in the adults, it would be inadvisable to conclude that such a difference is constant and of any value, without a much larger series of both species than has so far been available.

The excellent description given by Busck[1] of the adult of *P. gossypiella* is thus at present just as applicable to *P. scutigera*. No doubt differences do exist, and will undoubtedly be discovered. For the present, however, the larvae and adult genitalia must serve to distinguish the two species. Detailed descriptions of all the immature stages are to be found in the original paper on the pink bollworm of Queensland published in 1926[3].

Fig. 7. *Pectinophora gossypiella*, tegumen, gnathos, and uncus.

The rules of zoological nomenclature contain no restrictions on the making of a new species from immature stages. It is nevertheless a procedure which is inadvisable as a general practice. However, cases do arise in which there is no doubt that different species are represented, even though the adults apparently defy distinction. The pink bollworm constituted such a case. It was therefore felt that the importance of the economic problems centring round this nice taxonomic point were such as to warrant the procedure of designating a new species from larval material. The types thus consist of larval skins, of which the holotype is lodged in the British Museum (Natural History), and the paratypes in the Australian Commonwealth collection at

Canberra City, F.C.T., and the U.S. National Museum, Washington, D.C. Plesiotypes in the form of male genitalia mounts are also lodged in the collections of the above-mentioned institutions.

Fig. 8. The signa of the female bursa copulatrix: *a*, *Pectinophora scutigera*; *b*, *P. gossypiella*.

*Acknowledgments.*

The adults of *P. gossypiella* used in the present study were supplied by Rao Sahib Y. Ramachandra Rao, Government Entomologist, Coimbatore, India, and his assistance in this connection is gratefully acknowledged. I am also indebted to Mr. August Busck, of the U.S. National Museum, for the loan of additional mounts of the male and female genitalia of both species. The *gossypiella* material from which these latter mounts were made included specimens from India, Egypt and Texas, U.S.A.

*Summary.*

A study of the genitalia of both sexes of the Queensland pink bollworm, *Pectinophora scutigera*, Holdaway, originally named from the immature stages, has confirmed the validity of the species. Details of a comparative study of the genitalia of this species and *Pectinophora gossypiella*, Saunders, are given and figured.

*References.*

(1) Busck, A. 1917. The Pink Bollworm, *Pectinophora gossypiella*.—J. Agr. Res. ix, pp. 343–370, figs. 1–7, pls. vii–xii.

(2) Busck, A. & Heinrich, C. 1921. On the Male Genitalia of the Microlepidoptera and their Systematic Importance.—Proc. Ent. Soc. Wash. xxiii, pp. 145–152, pls. xii–xiii.

(3) Holdaway, F. G. 1926. The Pink Bollworm of Queensland.—Bull. Ent. Res. xvii, pp. 67–83.

(4) Holdaway, F. G. 1929. The Pink Bollworm Situation in Australia.—Proc. 4th Int. Ent. Congr., Ithaca, N.Y., Aug. 1928, pp. 79–86.

(5) Pierce, F. N. 1909. Genitalia of Lepidoptera, Noctuidae. Liverpool.

(6) Ripley, L. B. 1924. The External Morphology and Postembryology of Noctuid Larvae.—Ill. Biol. Monogr. viii, no. 4, pp. 1–102.

# CASTNIOMERA HUMBOLDTI (BOISDUVAL), A PEST OF BANANAS.

By George Salt, D.Sc., F.E.S.

(Plate X.)

For a number of years reports have been received from the banana-growing districts of Central and northern South America of a large white grub occasionally discovered in extensive borings in the base of banana pseudostems. While in the Santa Marta region of Colombia, the writer readily succeeded in rearing the adult, which turned out to be the Castniid moth, *Castniomera humboldti* (Boisduval), and was able to devote a short time to the study of the insect, discovering not only that it is far more abundant than has been supposed, but also that its presence has a very serious effect on the production of bananas.

The injury done by *Castniomera humboldti* depends upon the boring habits of its larva, which tunnels in the base of banana pseudostems for food. The larval galleries (Plate X, fig. 1) extend from the level of the ground to a height of one or sometimes even two metres. As a rule, they pass rather directly upwards with only a slight tendency to wander. They are usually superficial, affecting only the outer leaf-sheaths, but there are sometimes short branches penetrating the tissues to a depth of five or ten centimetres. At the extreme base of the pseudostem and in the tougher tissues of the rhizome, the galleries are more tortuous and often transversely extensive (Plate X, fig.2). They are blocked, in part, with frass ; and the torn tissues forming their walls become infected with fungi and turn black. In addition the galleries invariably contain large quantities of a clear gelatinous substance which is exuded from the injured surfaces and which runs down the galleries and out at the opening below.

Young plants, the suckers, may be actually killed by the boring, which often entirely interrupts the development of their new leaves. An older infested plant, however, usually shows little or no outward sign of its condition. As the gallery is superficial, the new, innermost leaves continue to develop unhindered. The water and food supply of the older fronds, whose bases are affected, are not completely cut off, and they remain green. A streak of discoloured tissue on one side of the pseudostem, marking the position of the gallery, is the most that one sees of the injury. Almost always, however, a puddle of the jelly-like exudate at the base of a plant serves to indicate its condition.

The economic significance of the attack is rather obscure. Suckers may be killed, pseudostems may be weakened, growth may be retarded, and occasionally (one example was seen) a larger and deeper gallery than usual may kill even a well-grown plant ; but as a rule the apparent effect of the boring is slight. There is, however, a definite and important economic result. It is to be found in the reduced size of the bunches of fruit produced by infested plants.

In the course of a survey made by my assistant, Mr. S. A. Svenningsen, 193 infested plants were considered, of which 77 were bearing bunches of fruit as follows :—

| | | | | | |
|---|---|---|---|---|---|
| 11 | bunches with | 4 | hands ... ... ... | 44 | hands. |
| 11 | ,, ,, | 5 | ,, ... ... ... | 55 | ,, |
| 26 | ,, ,, | 6 | ,, ... ... ... | 156 | ,, |
| 19 | ,, ,, | 7 | ,, ... ... ... | 133 | ,, |
| 9 | ,, ,, | 8 | ,, ... ... ... | 72 | ,, |
| 1 | ,, ,, | 9 | ,, ... ... ... | 9 | ,, |
| 77 | bunches with a total of | | ... ... ... | 469 | hands, |

or an average of 6·1 hands per bunch.

Each infested plant bearing fruit was compared with a healthy plant immediately adjacent to it, often with an unattacked plant in the same mat. These 77 healthy plants were bearing fruit as follows :—

| | | | | | |
|---|---|---|---|---|---|
| 2 | bunches with | 7 | hands | ... ... ... | 14 hands. |
| 36 | ,, ,, | 8 | ,, | ... ... ... | 288 ,, |
| 37 | ,, ,, | 9 | ,, | ... ... ... | 333 ,, |
| 1 | ,, ,, | 10 | ,, | ... ... ... | 10 ,, |
| 1 | ,, ,, | 11 | ,, | ... ... ... | 11 ,, |
| 77 | bunches with a total of | | | ... ... ... | 656 hands, |

or an average of 8·5 hands per bunch.

The average reduction from 8·5 to 6·1 hands per bunch, apparently caused by the borer, is itself a considerable loss ; but when it is considered that bunches of fewer than seven hands are not normally used in export trade and that 62·3 per cent. of the bunches from infested plants were of this unprofitable class, the economic significance of the *Castniomera* is still more clearly revealed.

Surveys to determine the prevalence of this pest were carried out on only one farm, near Tucurinca, although infested plants were also observed near Rio Frio, Sevilla, and Aracataca.

After a preliminary survey had shown large plants or suckers, or both, attacked in six of ten mats, a larger survey on the same farm considered 28 rows of 26 mats each. Of these 728 mats, 174, or 23·9 per cent., had one or more grown plants attacked, and an unknown number of others had infested suckers, which, unfortunately, were not counted. Lastly, of the 52 mats composing two rows close to these, 29, or 55·8 per cent., were found to be attacked by the borer, 10 having both grown plants and suckers attacked, 5 large plants alone, and 14 suckers alone. As many as five suckers were found eaten in a single mat.

The banana moth borer, then, can be said to occur in all parts of the Santa Marta region. In the one locality where it was thoroughly studied it was present in either grown plants or suckers in 55·8 per cent. of the mats, and in grown plants alone in 23·9 per cent. of the mats. It is unlikely that the prevalence of the borer is as high as this in very many places in the region, but the attack is so insidious that one can feel no assurance on the point until extensive and detailed surveys are made.

The life-history of *Castniomera humboldti* is still incompletely known, the egg stage not having been studied by the writer. Adult females were often observed fluttering about young banana suckers and settling upon them as though in the act of oviposition, but later examination of the plants did not reveal the presence of eggs.

The full-grown larva (fig. 1, *f*) is cream-coloured ; the head, marks on the prothoracic shield, the thoracic legs, the margins of the spiracular clefts, and a mark on the anal segment, brown. With very few hairs. Length 7 to 7·5 cm. Width at mesothoracic segment 1·4 cm. Head somewhat flattened, reddish brown, darker anteriorly, with two elongate, triangular, yellow marks extending forward from the posterior margin. Occipital margin deeply notched but hidden by the prothoracic shield. Adfrontal sclerites extending forward to the clypeus ; frons dark brown deepening to black anteriorly ; clypeus light brown, its apex straight but with slightly protruding lateral angles. Antennae light brown, three-jointed, with a long hair arising from the end of the second segment, the third article very small. Six ocelli arranged in a hollow rectangle behind each antenna ; the anterior ventral the largest, the two anterior lateral well developed, the two dorsal and the posterior ventral nearly obsolete. Mandibles dull black, smooth at the tip, sculptured basally. Maxillae and labrum cream-coloured, marked with brown. Thorax with three pairs of light brown, three-jointed legs. Prothoracic shield transverse ; 1·2 cm. wide and

0·7 cm. long ; cream-coloured with various reddish-brown and dark markings. Prothoracic spiracle large, on the posterior margin of the segment, deeply inset. Meso- and metathoracic segments the widest part of the body, transverse, 1·4 cm. wide ; each dorsally, on the vertex and ventrally, between the legs, with a transverse area of

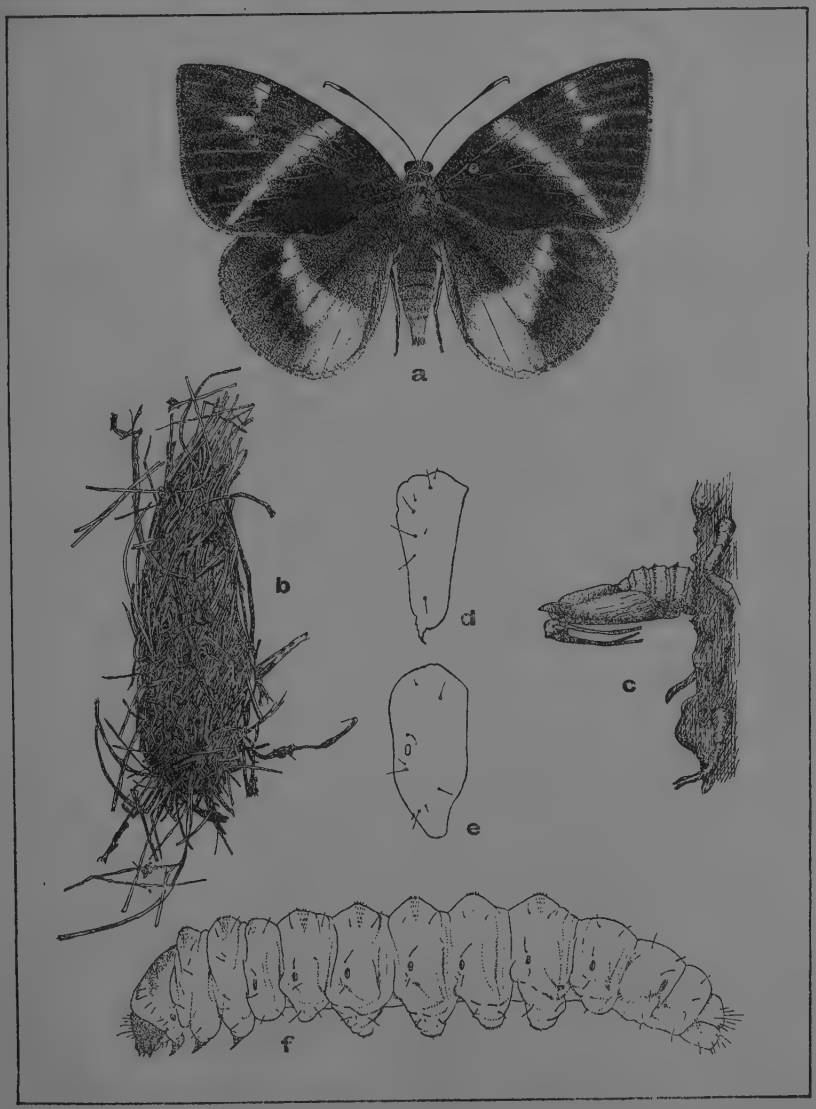



Fig. 1. *Castniomera humboldti*, Boisd. : *a*, adult ; *b*, cocoon ; *c*, empty pupal case protuding in characteristic position from the base of a banana pseudostem ; *d*, arrangement of setae on mesothoracic segment, and *e*, on 3rd abdominal segment, of full-grown larva ; *f*, full-grown larva (*a*, *b*, and *c* × $\frac{3}{4}$; *f* × $1\frac{1}{4}$).

very short, thick, closely situated, black spicules, and with a similar but much smaller area on each side just above the legs. Segments 1 to 8 of the abdomen each with a pair of spiracular clefts, oval in outline, and narrowly margined with brown; the anterior pairs situated at the front of their respective segments, the posterior pairs successively farther back, so that the eighth pair is placed near the posterior margin of the segment; the eighth pair larger and situated more dorsally than the others. The first seven abdominal segments with dorsal transverse areas of the short spicules, which however are not as well developed as on the meso- and metathoracic segments, and on the first, second, and seventh segments are quite small. The abdominal prolegs bear an apical patch of short spicules like those present on the dorsal surface, without hooks, arranged in two transverse lines across each proleg, with a longitudinal patch on the outside. The anal segment with an irregular brown mark on the dorsal surface and a few more hairs than are found on the other segments.

The arrangement of the setae on the mesothoracic segment (fig. 1, *d*) is as follows: I and II together, dorsal; III and IV together, below I and II and a little forward, III small; V large, below IV, with a small secondary (?) seta posterior to it; VI below V and near it; VII on the base of the leg. On the third abdominal segment (fig. 1, *e*), I is anterior and dorsal to II; II behind the area of spicules and opposite its edge; III just above the spiracle; IV and V together below the spiracle, IV very small; VI posterior on the base of the leg; VII a group of three, anteriorly, on the base of the leg, the middle one large, the others small. The arrangement of the setae on the abdominal segments agrees exactly with that described by Dyar (1905) for *Castnia licoides*; the arrangement on the thorax, however, appears to be different.

Smaller larvae of unknown instar differ from the above description in only a few characters. One, four centimetres long, has the head and prothoracic shield somewhat darker and not so definitely marked, the spiracular clefts less conspicuous, and the anal segment not marked dorsally. The arrangement of its setae is exactly as described above, but the abdominal prolegs differ in that each bears two opposing rows (uniserial bands) of hooks and the anal proleg carries a single row. These hooks are conspicuous and well-developed in this instar although completely absent in the full-grown larva. Another larva, only 1·5 cm. long and the smallest examined in detail, also has these hooks on the prolegs. In this last the eighth spiracle is relatively enormous, the hairs on the last three segments comparatively long, and the setal arrangement exactly as described, except that the small setae of the group of three forming VII on the abdominal segments are scarcely visible.

As no individual was brought through the larval stage from egg to pupa, the duration of the period is not known. One which was about 4 cm. long when obtained on 31st May, moulted on 1st June and again on 14th June, and constructed its cocoon on 1st July. Another larva, 3 cm. long when found, constructed a cocoon 33 days later. The young larvae, under 3 cm. in length, were always obtained from suckers. The smallest larva found in an older plant was one 3 cm. long and was taken in a short gallery extending from a hole at ground-level to a height of only 15 cm. Judging from the many galleries examined, it would seem that the young larva feeds for the first part of its life in the tender tissues of the young suckers, then passes across to the base of an older plant, which it enters at about the level of the ground. The larva then proceeds at once to bore its long, vertical gallery up the pseudostem and returns to eat the tougher tissues of the rhizome later, when nearly full-grown.

When disturbed, the larvae are able to discharge a stream of liquid from the mouth to a distance of several inches. If picked up they turn and try to catch the fingers with their strong mandibles. Larvae are readily reared in small sections of banana pseudostem, a foot long and six to ten inches in diameter. A small pit may be made in one side, the larva placed within, and the cavity capped by a piece of the tissue

removed. The larva remains in its section. The pieces should be changed every two or three days. In Colombia the larva is known as the " purgón " ; in Central America it is said to go by the curious name " gallina ciega."

Shortly before pupation the larva constructs a cocoon (fig. 1, *b*) of fibres of the banana plant cemented and hardened by a secretion of its own. Within the cocoon it shortens considerably and enters a pre-pupal stage of about four days' duration ; some specimens did not pupate until six days after the cocoon was completed.

The pupa is brown ; the sutures, labrum, rows of teeth on the abdomen, spiracular clefts, and most of the anal segment dark brown. Smooth and shining. Length 4 to 4·5 cm. Width across the mesonotum 1·2 cm. Front with a transverse ridge just before the clypeus ; labrum transversely raised ; mandibles prominent ; labial palpi short ; maxillary palpi well developed, reaching the gena and maxilla ; maxillae long, reaching the wings and passing between and separating the pro- and mesothoracic legs of the two sides ; femora of prothoracic legs narrowly visible ; antennae extending a little beyond the maxillae ; wings reaching the middle of the fourth ventral segment, their caudal margins free ; metathoracic legs extending beyond the wings to the base of the fifth segment, their tips free. Dorsum with a distinct median ridge from the vertex to the metanotum ; mesothoracic spiracular cleft crescent-shaped ; the abdominal spiracles more rounded ; that on the eighth segment barely indicated. Second to seventh abdominal segments dorsally each with two transverse rows of teeth directed backwards, the rows on segment 2 not reaching the spiracles laterally, those on segment 3 about attaining the upper margin of the spiracles ; those on segments 4 to 7 passing slightly beyond the spiracles on the side. Segment 8 with one prominent row of teeth and a second barely indicated by a few obsolete projections dorsally ; segment 9 with a single, well-developed row. Last segment truncate apically, ridged dorsally ; anal opening simple, slit-like ; genital opening on a slight tubercle.

The duration of the pupal stage in the specimens reared varied between 26 and 35 days, the average period being about 32 days. The cocoon is constructed near the base of the plant with a boring to the outside readily accessible. Shortly before emergence the pupa escapes from its fibre cocoon and by means of the rows of teeth on its abdomen, moves along the passage to the outside. Pupal cases from which the adult moth has emerged are frequently found half jutting from the gallery at the base of the pseudostem (fig. 1, *c*). A cocoon which was removed from a gallery became quite dry and hard in the open air. A day after it has been examined and found in that condition, the adult emerged and the pupal case was pushed partly out from the cocoon. Upon examination it was found that the anterior fibres of the cocoon were quite wet and pliable, apparently made so by a fluid secreted to aid the emergence.

The moth was described by Boisduval in 1874, and both sexes have recently been admirably figured by Houlbert (1918). No formal description of the adult need here be given, and a few notes on colour to supplement the sketch (fig. 1, *a*) should suffice for its recognition. The anterior wings in a fresh specimen are very dark brown, traversed by a diagonal line of dirty white, and with irregular apical marks of clear white. The brown of the secondaries is much more inclined to be reddish, especially immediately outside the white band. The body is dark brown, paling to dirty white posteriorly. The collar-lappet, tegulae, and bases of the wings bear large scales which shine green and blue in some lights ; indeed, in fresh specimens, the entire surface of the wings has a purplish reflection.

The adult is an active insect, wary, and of speedy and erratic flight, so that it is somewhat difficult to capture. Although diurnal and usually seen on the wing on bright days between 8.30 and 11.00 in the morning, it is a lover of shadow rather than sunlight and keeps well within the shady aisles of the banana plantations, seldom venturing farther into the open than is necessary to cross a road or a narrow stream.

The moths frequently fly in pairs, chasing each other through the rows of bananas. They usually rest upon upright surfaces, the pseudostem of the bananas, a dead, hanging leaf, or a tree-trunk, and have a common habit of settling on the pseudostem of young suckers at a height of 7 or 8 cm. from the ground. Upon alighting, the moth folds its wings along the back, the white bands of the primaries meeting to form a continuous white mark across the brown triangle of the folded wings. Ripe and rotting banana fruits seem to have some attraction for the adults, which frequently settle amid the host of fruit-flies on bananas left in the field.

*Castniomera humboldti* appears to be confined to Colombia and Venezuela. It was originally described from the former country. Houlbert (1918) records six specimens, from Muzo and Toquiza, Colombia, and San Estevan, Venezuela. Lathy (1922) records a single male from Muzo, Colombia. Rothschild (1919), who considers *humboldti* a variety of *Castnia atymnius*, lists eight specimens, all from Colombia; six from Rio Dagua, one from Bogotá, and one from Sta. Fé de Bogotá. Strand (1913) mentions Colombia and Central America as the home of the species, but Houlbert (1918) points out that his *C. humboldti* variety *rufolimba* is actually *C. drucei*, which occurs in Costa Rica, so that the Central American record requires confirmation. The larvae reported as feeding on bananas in Central American plantations have not been raised for identification.

The CASTNIIDAE have already become notorious as enemies of plants of economic importance. Chief among them, and best known, is *Castnia licoides*, Boisduval (*C. licus*, auctt.), which for a number of years was a major pest of sugar-cane in British Guiana and some of the Lesser Antilles. It was studied and an account of it published by Marlatt (1905). *C. licoides* has also been reported as occasionally attacking bananas and plantains in Trinidad and South America (Fawcett, 1913; Bodkin, 1916). *Castnia daedalus* is a common pest of coconut palms in British Guiana (Bodkin, 1913b) and has been reported as attacking bananas in Dutch Guiana (Reyne, 1923). Several other species, including *C. acraeoides*, Gray (Grünberg, 1909), *C. therapon*, Kollar (Weiss, 1916), and *C. eudesmia*, Gray (Philippi, 1863) have been reared from larvae living in the bulbs and rhizomes of orchids and bromeliads. The last, it is interesting to note, causes its bromeliaceous host, *Pourretia coarctata*, to produce a gummy substance apparently similar to that which flows from infested bananas (*cf.* p. 187).

The sugar-cane pest, *Castnia licoides*, has been successfully dealt with in British Guiana, according to Wolcott (1913), who suggests four methods of control: (1) Collecting of the adult moths in butterfly nets; (2) cutting out the young larvae from the young ratoon cane; (3) cutting out the older larvae and pupae from the stools of cane after the crop has been harvested; (4) in the case of very heavy infestation, the flooding of an entire field after the cane is cut. Several species of birds, including *Crotophaga ani* and *Pitangus sulphuratus* are known to prey upon the adult in British Guiana (Bodkin, 1913a).

In the short time devoted to its study, no experiments on the control of *Castniomera humboldti* were possible. Of the methods suggested by Wolcott for the control of *C. licoides* in cane, only the first would seem to be directly applicable to the banana moth borer. The moths might be attracted to a poisoned bait, and the cutting out and destruction of the younger larvae from the suckers might furnish a parallel method to that most successful for the cane borer, but neither has yet been tried. A further and much more exhaustive study of the habits and local distribution of the pest will be necessary before control measures may be confidently recommended.

My thanks are due to Doctor W. Schaus of the Bureau of Entomology, U.S. National Museum for determination of the insect herein discussed. I am deeply indebted to my friend Mr. S. A. Svenningsen for his assistance in the field work.

*References.*

BODKIN, G. E. 1913a. Insects injurious to sugar-cane in British Guiana, and their natural enemies.—Jour. Bd. Agric. Br. Guiana 7 (1), pp. 29–32.

1913b. A new insect pest of coconut palms in British Guiana, *Castnia daedalus* Cramer.—Jour. Bd. Agric. Br. Guiana 7 (2), pp. 87–90.

1916. Report of the economic biologist.—Rept. Dept. Sci. and Agric. Br. Guiana, for the nine months ended 31st December 1915. Georgetown, 10 pp. (Abstract in Rev. App. Ent. (A) 5, pp. 169–170.)

BOISDUVAL, J. A. 1874. Species Général des Lép. Hét., I, Sphingides, Sésiides, Castnides, iv+567 pp., 11 pls.

DYAR, H. G. 1905. Larva of *Castnia licus* Drury.—Proc. Ent. Soc. Washington 7, pp. 83–84.

FAWCETT, W. 1913. The banana, its cultivation, distribution, and commercial uses.—London, x+287 pp., 8 pls., 10 figs.

GRÜNBERG, K. 1909. Zur Metamorphose von *Castnia acraeoides* Gray.—Deutsch. Ent. Zeitschr. 1909 (1), pp. 127–130, 2 figs.

HOULBERT, C. 1918. Révision monographique de la Sous-Famille des Castniinae. —Et. Lép. Comp. Oberthür., fasc. 15 ; xvi+730 pp., 26 col. pls., 242 figs.

LATHY, P. I. 1922. An account of the Castniinae in the collection of Madame Gaston Fournier.—Ann. Mag. Nat. Hist. (9) 9, pp. 68–86.

MARLATT, C. L. 1905. The Giant Sugar-cane Borer (*Castnia licus* Fabr.).—U.S. Dept. Agric., Bur. Ent. Bull. 54, pp. 71–75, 1 pl.

PHILIPPI, R. A. 1863. Metamorphose von *Castnia*.—Stett. Ent. Zeit. 24 (10–12), pp. 337–341, 1 col. pl.

REYNE, A. 1923. Verslag van den Entomoloog.—Dept. Landbouw, Nijverheid, Handel Suriname. Verslag 1922. Paramaribo, pp. 32–39.

ROTHSCHILD, LORD. 1919. Supplementary notes to the review of Houlbert and Oberthür's monograph of Castniinae by Talbot and Prout.—Nov. Zool. 26 (1), pp. 1–27.

STRAND, E. 1913. The American Bombyces and Sphinges.—Seitz Macrolep. World (II) 6, pp. 3–31, 8 col. pls.

WEISS, H. B. 1916. *Gonepteryx rhamni* Linn. and *Castnia therapon* Koll. in New Jersey.—Jour. Econ. Ent. 9 (3), p. 378.

WOLCOTT, G. N. 1913. Report on a trip to Demerara, Trinidad and Barbados during the winter of 1913.—Jour. Econ. Ent. 6 (6), pp. 443–457, 2 pls.

Fig. 1. Gallery in an old banana pseudostem made by *Castniomera humboldti*, Boisd.

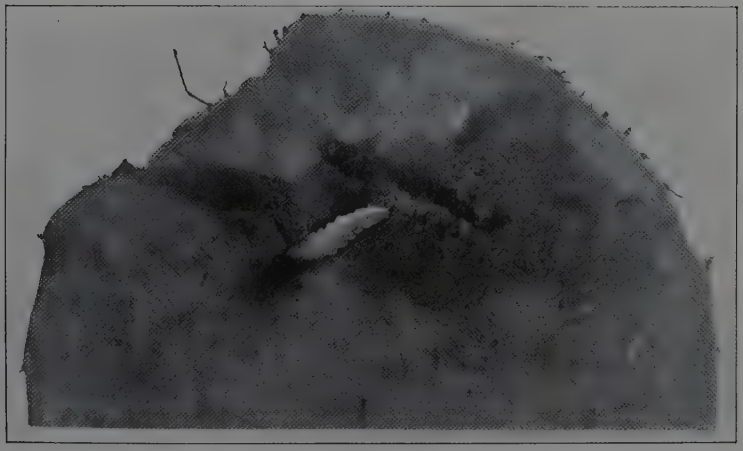


Fig. 2. Larva of *C. humboldti* boring in the rhizome.

# THE GRAPHICAL REPRESENTATION OF INSTAR RECORDS IN A REGIONAL MOSQUITO SURVEY.

By J. F. Marshall, M.A., and J. Staley,
*British Mosquito Control Institute, Hayling Island.*

Since the opening of the British Mosquito Control Institute, in August 1925, the mosquito control of Hayling Island (initiated in August 1920) has been carried on as part of the research work of the Institute's laboratory.

This work involves the routine examination of the different water-places of the Island throughout the year by an inspector who brings to the laboratory all specimens of mosquito larvae, etc., thus collected. These specimens are identified, recorded in the daily register and finally utilized in various ways; the larvae remaining in the water-places being subsequently destroyed by appropriate means. The inspector's working year is therefore made up of "collecting days" and "anti-larval days"; the time devoted to these two departments of the work being approximately the same.

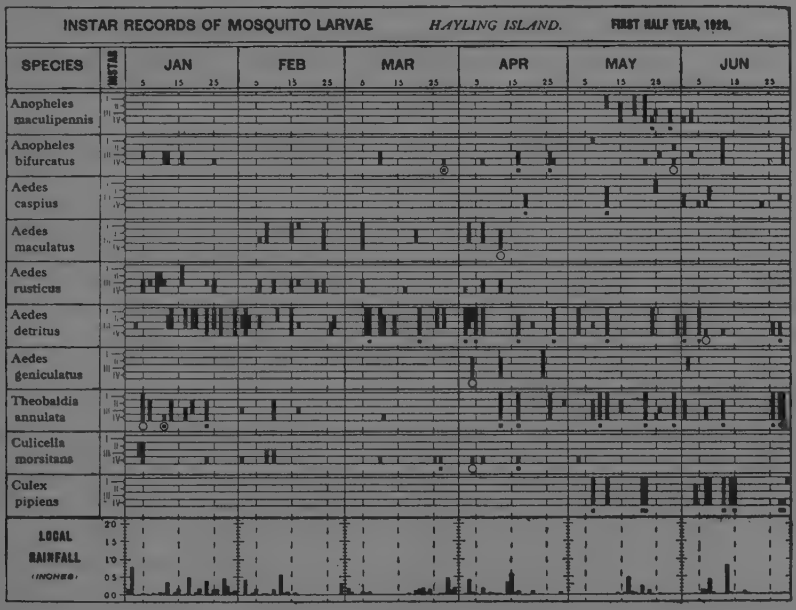



Figure 1.

It being thought that some graphical representation of the species and instars of the mosquito larvae thus recorded throughout each year might be of scientific interest (especially if similar records from other districts could be obtained for comparison), this Institute has recently made experiments with a view to devising some form of diagram which should not only be easy to "plot" but also easy to interpret, even if reproduced on a much reduced scale.

The method which has been finally adopted is shown in the accompanying illustrations, which are about one-fifth the size of the actual diagrams themselves.

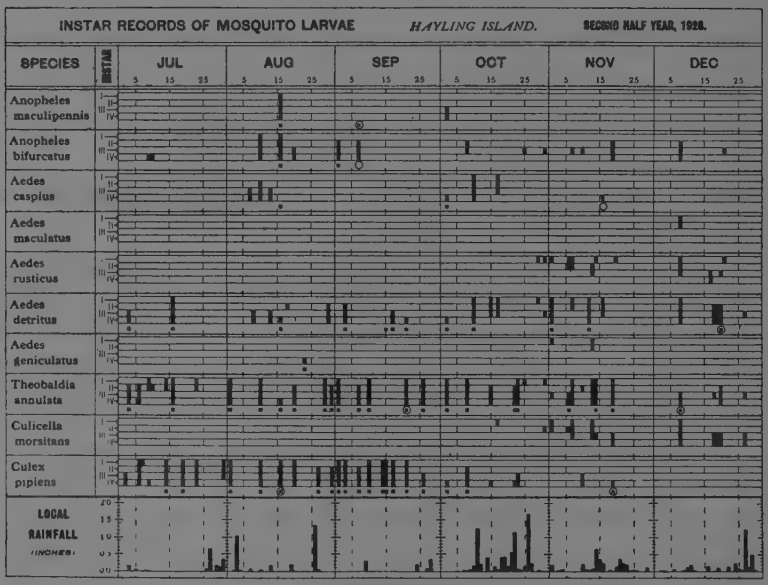



Figure 2.

It will be noted that each diagram is primarily divided (a) *horizontally*, into as many spaces as there are species to be recorded ; and (b) *vertically*, into spaces representing months. These primary divisions are themselves subdivided ; each of the horizontal ones into four horizontal strips representing *larval instars*, and each of the vertical ones into vertical strips representing the days of the month.*

The species and instars of the various larvae that are collected on any given date are indicated simply by inking-in the rectangular areas common to the instar-strips and the date-strips concerned.

Sufficient space is provided below the instar-strips for the insertion of any desired symbols, reference letters, etc., relating to the specimens thus recorded. In the particular diagrams here shown, the *square dots* indicate that pupae were collected ; the *circles*, that some fact of special interest was recorded in the daily register. The register entries to which attention is thus directed are reproduced in Table I.

A chart of the local daily rainfall is embodied in each of the diagrams, these charts being prepared from data kindly supplied by Mr. E. S. McEuen.

It need scarcely be pointed out that the instar records represented in figures 1 and 2 must, for many purposes, be supplemented by the detailed information obtainable from the register of specimens. For instance, the occurrence of two or more species in the same date-strip gives no indication as to which of the said species were found *alone* and which *in association with other species.*

This additional information is provided by Table II, in which each different larval association is indicated on a separate horizontal line by the insertion of crosses in the

* The vertical lines which form the date-strips are necessarily invisible on the reduced scale of the accompanying figures. The date-strips for the 5th, 15th and 25th of each month are therefore provided with thick centre lines to serve as a guide.

species columns concerned ; the number of records made of each particular association being given at the end of the line. Thus, for example, the Table shows that *Theobaldia annulata* was recorded 112 times ; the larvae being found *alone* on 35 occasions and associated with other species (in 18 different ways) on 77 occasions. Of these associations, it will be noted that 29 were with *Culex pipiens* ; 9 with *Anopheles bifurcatus* ; 7 with *Anopheles bifurcatus* and *Culex pipiens* ; 6 with *Aëdes detritus* ; 4 with *Aëdes rusticus* ; 2 with *Anopheles maculipennis* and *Culex pipiens*, and so on.

In Table II some pH and salinity records of special local interest are included. The latter are given in the form of percentages, the salinity of sea-water of an assumed chlorine content of 19·315 parts per 1,000 being taken as 100.

TABLE I.

*Notes of Special Interest Recorded on Dates Indicated by Circles in Figures* 1 *and* 2.

| Register Number. | Date (1928). | Species of larva. | Notes from Specimen Register. |
|---|---|---|---|
| 3184 | January 5 | *T. annulata* | Numerous 1st instar larvae, implying December oviposition. |
| 3196 | January 11 | *T. annulata* | Earliest pupal record for 1928. |
| 3329 | March 28 | *A. bifurcatus* | Earliest pupal record for 1928. |
| 3341 | April 4 | *A. geniculatus* | First larval record of this species in Hayling Island. |
| 3343 | April 4 | *C. morsitans* | With *C. fumipennis*, 4th instar. |
| 3360 | April 12 | *A. maculatus* | With *A. rusticus* in water of pH 6·9. |
| 3457 | May 3 | *A. bifurcatus* | With *A. detritus* and *T. annulata* in water of salinity 36 per cent. |
| 3472 | June 7 | *A. detritus* | One larva, in a water butt with *C. pipiens*. Salinity 0. Anal gills unusually long. |
| 3504 | June 29 | *T. annulata* | With *C. pipiens*, *A. bifurcatus* and *T. subochrea* in farmyard ditch. |
| 3570 | August 16 | *T. annulata* | With *C. pipiens* in disused well containing water of salinity 19 per cent. with *A. maculipennis* and *T. annulata*. |
| 3607 | September 7 | *A. bifurcatus* | With *A. maculipennis*, *T. annulata* and *C. pipiens* in a drinking trough. |
| 3624 | September 20 | *T. annulata* | With *A. detritus* and *C. pipiens* in water of salinity 10 per cent. |
| 3625 | September 20 | *T. annulata* | With *T. subochrea*. In several of the *T. subochrea* adults subsequently hatched, the posterior cross-vein was outside the mid cross-vein. |
| 3700 | November 16 | *A. caspius* | Latest larval record for Hayling Island. Pupated in laboratory November 21. Emerged November 25. |
| 3701 | November 19 | *C. pipiens* | Latest larval and pupal record for 1928. |
| 3707 | December 8 | *T. annulata* | Latest pupal record for 1928. |
| 3716 | December 20 | *A. detritus* | Latest pupal record for Hayling Island. |

TABLE II.

*Association Records of Mosquito Larvae Collected at Hayling Island During the Year* 1928.

| Species collected. | | | | | | | | | | No. of times found associated | Notes regarding salinity, pH, etc. (*The figures in brackets following each note indicate the register number of the particular collection of larvae to which the note refers.*) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *Anopheles maculipennis* | *Anopheles bifurcatus* | *Aëdes caspius* | *Aëdes maculatus* | *Aëdes rusticus* | *Aëdes detritus* | *Aëdes geniculatus* | *Theobaldia annulata* | *Culicella morsitans* | *Culex pipiens* | | |
| × | | | | | | | | | | 7 | |
| × | | | | | | | × | | × | 2 | |
| × | × | | | | | | | | | 1 | pH 7·3 (3569). |
| | × | | | | | | × | | | 1 | |
| | × | | | | | | × | | × | 1 | |
| | × | | | | | | | | | 7 | |
| | × | | | | × | | × | | | 9 | pH 6·9 (3517). |
| | × | | | | | | | | | 1 | |
| | × | | | | | | | | × | 1 | |
| | × | | | | | | × | × | | 3 | |
| | × | | | | | | × | | × | 7 | pH 7·5 (3518). Also *Theobaldia subochrea* (3504). |
| | × | | | | × | | × | | | 1 | Salinity 36 per cent. (3457) |
| | × | | | | × | | × | | × | 1 | |
| | × | | | | | | × | × | × | 1 | |
| | | | | | × | | × | × | × | 1 | |
| | | × | | | × | | | | | 15 | |
| | | × | | | | | | | × | 2 | |
| | | × | | | × | | | | × | 1 | Salinity 40 per cent. (3568). |
| | | | × | | | | | | | 5 | pH 5·2 (3319). |
| | | | × | × | | | | | | 7 | pH 6·1 (3288); 6·4 (3289); 6·9 (3360). |
| | | | × | × | | | | × | | 4 | pH 6·6 (3708). |
| | | | × | × | | | × | | | 1 | |
| | | | | × | | | | | | 31 | pH 6·8 (3653). |
| | | | | × | | | × | | | 4 | |
| | | | | × | | | | × | | 6 | |
| | | | | × | × | | | | | 1 | |
| | | | | × | | | × | × | | 2 | |
| | | | | × | × | | | × | | 3 | pH 8·1 (3220); 6·9 (3672); 6·7 (3711). Salinity 8 per cent. (3711). |
| | | | | × | × | | × | × | | 3 | pH 6·2 (3687); 6·5 (3688). |
| | | | | | × | | | | | 107 | |
| | | | | | × | | × | | | 6 | |
| | | | | | × | | | × | | 1 | |
| | | | | | × | | | | × | 2 | |
| | | | | | × | | × | | × | 3 | Salinity 10 per cent. (3624); 14 per cent. (3625). |
| | | | | | | × | | | | 7 | pH 6·2 (3341); 6·4 (3689). |
| | | | | | | | × | | | 35 | |
| | | | | | | | × | × | | 2 | |
| | | | | | | | × | | × | 29 | Salinity 19 per cent. (3515). |
| | | | | | | | × | × | | 24 | pH 6·2 (3641); 5·8 (3643). Also *C. fumipennis* (3343). |
| | | | | | | | | | × | 23 | |
| | | | | | | | | | | 368 | Total number of larval collections examined. |
| 12 | 35 | 18 | 17 | 62 | 136 | 7 | 112 | 50 | 74 | Total number of records of each different species. | |

# ON THE IDENTITY OF THE COMMON DIPTEROUS PARASITE OF THE LARVA OF *DIATRAEA SACCHARALIS*, FABR., IN THE NORTHERN PROVINCES OF ARGENTINA.*

By Harold E. Box, F.E.S.

The first reference to the existence in Argentina of the parasite that is the subject of the present article appears to be that of Messrs. Rosenfeld & Barber[1], who, for lack of a more exact determination, referred to it as "*el parásito díptero*" or "*el díptero.*" Some time after the appearance of their publication, these entomologists sent specimens to the late Dr. Frederick Knab, who determined them as *Sarcophaga ochropyga*, van der Wulp; these specimens had been reared from *Diatraea saccharalis*, Fabr. (sugar-cane moth borer) at the Tucumán Agricultural Experiment Station, and were later incorporated in the collection of that institution under the "accession number 47," and bore labels indicating Dr. Knab's identification.

In 1926, the late distinguished Argentine entomologist, Dr. Juan Brèthes, came across these specimens whilst looking over this Station's collection of Diptera, and took them away for study. He found that they differed in several respects, notably in the colouration of the antennae and tegulae and in the characters of the dorso-central macrochaetae, from *ochropyga*, Wulp, and described the species as new, under the name *Sarcophaga diatraeae.*[2]

Meanwhile, we find that Messrs. Holloway, Haley & Loftin state, in the section devoted to the parasitic enemies of *Diatraea* in their standard work[4] on this pest, that "according to Dr. Townsend, Rosenfeld and Barber's 'dipteron' . . . [is] *Oxysarcodexia peltata*, Aldrich."† The present writer does not know upon what material Dr. Townsend based this determination, as there is no record in this Station of the sending of specimens to him.

Last year the writer sent a few specimens of this Station's "accession number 47" to Dr. Aldrich at the United States National Museum, Washington. These were actually paratypes of *Sarcophaga diatraeae*, Brèthes, and bore Dr. Brèthes' name-labels, those of Dr. Knab with the determination of *S. ochropyga* having been removed. In his report upon these specimens, Dr. Aldrich stated that the species is, without doubt, *Paratheresia signifera*, Townsend (Dexiidae), and not his own *Oxysarcodexia peltata*, this latter being an entirely different insect, and a true Sarcophagid‡ known to occur in many parts of Central America and the West Indies.

---

* Being a Scientific Contribution from the Agricultural Experiment Station, Tucumán, Argentina. Revised translation from Revista Industrial y Agrícola de Tucumán, xix, nos. 5–6, pp. 132–133, Oct.-Nov. 1928.

† Originally described as *Sarcophaga peltata*; afterwards made the type of *Oxysarcodexia*, Townsend. Dr. Aldrich has recently informed me that this insect is *S. obtusifrons*, Thomson, of which name *peltata*, Aldrich, is a synonym.—H.E.B.

‡ I recently had the pleasure of meeting Dr. Townsend in Tucumán, and he informed me that the specimens he named for Mr. Rosenfeld were certainly *O. peltata*, but he expressed some doubt as to this species being parasitic on the larva of *Diatraea*. Dr. Aldrich has very kindly sent me some specimens of this fly, and they certainly bear a superficial resemblance to the Dexiid, *P. signifera*. As the photographs given by Rosenfeld & Barber correspond to *P. signifera*, I think it most likely that they had some of the Sarcophagids mixed with this species among their series of "accession number 47" and sent them to Dr. Townsend in mistake for the borer parasites. At that time the almost infallible character for separating Dexiidae and Tachinidae from Sarcophagidae and other Muscoid Diptera, *viz.*, the presence of the post-scutellum in the former and its absence in the latter, was not known, and indeed my own attention has but recently been drawn to it through the kindness of Mr. D. G. Hall.—H.E.B.

In view of the careful determination of our common borer parasite by Dr. Aldrich, it seems that we can now consider the name of *Sarcophaga diatraeae*, Brèthes, as no more than a synonym of *Paratheresia signifera*, Townsend.

This Dexiid is an important enemy of *Diatraea saccharalis* in Peru (from which country it was originally described), and it can be considered as one of the most efficient larval parasites of *Diatraea* known. In Argentina the writer has reared it in abundance from sugar-cane borers in the provinces of Tucumán, Salta and Jujuy, though to date there is no record of its occurrence in the Chaco, Misiones or Paraguay, from each of which territories consignments of borers have been received for examination. *P. signifera* seems to attack the new species of *Diatraea* recently discovered by the writer in Salta and Jujuy[5] to at least the same degree as it does *D. saccharalis*. In Tucumán the hyperparasite, *Aulatopria tucumana*, Brèthes (DIAPRIIDAE) has been bred from about 1 per cent. of the puparia of *P. signifera*.

In Tucumán, another Dexiid parasite of *D. saccharalis* occurs to a small extent; regarding this fly, Dr. Aldrich informs me that it may represent a new genus.

*Literature cited.*

(1) ROSENFELD, A. H. & BARBER, T. C. "El gusano chupador de la caña de azúcar (*Diatraea saccharalis* Fab. forma *obliteratellus* Zell.)."—Revista Industrial y Agrícola de Tucumán, año iv, pp. 229–366, 1914.

(2) BRÈTHES, J. "Parasites and Hyperparasites of *Diatraea saccharalis* in Tucumán sugar-cane."—Bull. Ent. Res., xviii, pp. 205–207, 1927. (Translated and reprinted from Rev. Ind. y Agric. de Tucumán, xviii, pp. 163–166, 1927.)

(3) HOLLOWAY, T. E. & LOFTIN, U. C. "The Sugar-cane Moth Borer."—U.S. Dept. Agric. Bull. 746, 1919 (p. 41, second foot-note).

(4) HOLLOWAY, T. E., HALEY, W. E. & LOFTIN, U. C. "The Sugar-cane Moth Borer in the United States."—U.S. Dept. Agric. Tech. Bull. 41, 1928 (p. 43, second foot-note).

(5) BOX, H. E. "Informe preliminar sobre el descubrimiento en la República Argentina de una especie de *Diatraea* nueva para la fauna americana."—Rev. Ind. y Agric. de Tucumán, xix, pp. 97–103, 1928.

# NEW CURCULIONIDAE (COL.) FROM CACAO AND CAMPHOR.

By Guy A. K. Marshall, C.M.G., D.Sc., F.R.S.

## Subfamily Brachyderinae.

**Ischnotrachelus theobromae,** sp. n.

♀. Derm black, covered with dense pale green scaling, varying to dull coppery; the head and legs normally coppery.

*Head* with the frons convex, raised much above the level of the eyes, and with a very shallow transverse impression on the vertex; the eyes much less prominent than usual, as in *I. viridipennis*, Fst. *Rostrum* longer than broad, parallel-sided, and set with short stout erect setae; the dorsum without distinct carinae, its lateral margins not angulated but rounded off, with a fine median stria in the basal half and a low carina at the apex; the scrobes strongly curved downwards in the basal half and there adjoining the lower margin of the eye. *Antennae* with the scape somewhat compressed, strongly dilated from the middle to the apex, and with its dorsal edge markedly sinuate; the funicle short and thick, widening distally, joint 1 longer than 2+3, 2–7 all transverse. *Prothorax* slightly longer than broad, gently rounded laterally, widest beyond the middle, and without any apical constriction; the apex a little narrower than the base and dorsally with a dense fringe of recumbent scale-like setae, the postocular vibrissae obsolete; the dorsum comparatively smooth, the sculpture being hidden by the scaling, with a mere trace of an abbreviated median stria near the base; the setae very short and recumbent behind, becoming slightly longer and suberect anteriorly. *Scutellum* minute or obsolete. *Elytra* rather narrow, oblong-ovate, with a shallow transverse impression at the base so that the margin is slightly raised; the striae and punctures almost entirely obliterated by the dense scaling; the intervals each with a row of small subrecumbent setae; the scales (like those on the prothorax) irregularly rounded and each with a shallow central puncture. *Legs* with a sharp tooth on all the femora; the anterior pairs of tibiae strongly denticulate, the hind pair with much smaller teeth.

*Length,* 4·8–5·0 mm.; breadth, 1·9–2·1 mm.

Fernando Poo: 4 ♀♀, ix.1928 (*G. S. Cotterell*).

Recorded as attacking the foliage of cacao trees.

Extremely similar to *I. viridipennis*, Fst. 1898, which, however, differs in the following characters:—The antennae have the scape cylindrical, slender, abruptly clavate only in the apical fourth, and with the dorsal edge almost straight; the funicle has joint 2 much longer than broad, 3 about as long as broad, and the rest transverse; the dorsal margins of the rostrum are angulate; the prothorax has no apical fringe; the scutellum is much larger; the hind tibiae are not denticulate; and the scales bear no puncture.

**Dermatodes camphorae,** sp. n.

♂♀. Derm black, with dense earth-brown scaling above, turning to grey beneath; the elytra with a slightly oblique, dark brown patch behind the middle on intervals 6 and 7, which sometimes extends inwards to the suture in the form of a very indefinite dark transverse band.

*Head* with the frons flat and covered with densely overlapping recumbent or subrecumbent scales, the median furrow narrow and sharply defined. *Rostrum* somewhat longer than broad, widening from base to apex; the disk impressed in the middle and with a median carina, but the surface so densely squamose as to appear almost flat and with the carina entirely hidden; the epistome elevated and bearing

a deep lunate impression. *Antennae* with the joints of the funicle in order of length : (1, 2), 3, (4, 5, 6, 7), joint 3 longer than broad, 4–6 about as long as broad, and 7 transverse and with its apex somewhat produced externally. *Prothorax* slightly broader than long, gently rounded at the sides, and widest a little beyond the middle ; the apical margin truncate dorsally, straight at the sides and there vertical or sloping slightly backwards ; the dorsum rugulose, without any median furrow or shiny granules. *Elytra* ovate, with the shoulders rounded (the wings being rudimentary), widest about the middle ; the dorsal outline rising gradually to behind the middle in the ♂ and steeply declivous behind, in the ♀ rising sharply for a short distance at the base and continuing with a flattened curve to the top of the declivity ; the coarse shallow punctures in the striae so much covered by scaling as to appear like a narrow continuous line, without any contained setae ; the intervals broad, 1, 3, 5 and the basal fourth of 7 distinctly elevated and costate, 1 being especially prominent on the upper half of the declivity ; the dorsal intervals without any trace of granules but with rows of subrecumbent spatulate dark setae, intervals 7–10 with distinct shiny black granules. *Legs* with the anterior pairs of tibiae only slightly curved, the teeth on the hind pair of ♂ very small and inconspicuous.

*Length*, 1·7–3·3 mm. ; breadth, 4·2–7·2 mm.

Java : Buitenzorg, 16 ♂♂, 16 ♀♀, defoliating *Cinnamomum camphora*, 1929 (*L. G. E. Kalshoven*—type) ; Papandajan, 4 ♂♂, 7 ♀♀, iv.1909 (*G. E. Bryant*) ; Kawah Manoek, 4 ♀♀, iv.1909 (*Bryant*).

Allied to *D. elevatus*, Pasc., in general facies and in the costate elytra, but this latter differs in having the pronotum much more rugose and with a distinct broad median furrow ; and the raised costae on the elytra are uneven and bear much larger and darker lancet-shaped setae.

*D. costatus*, Gyll., differs in having the head broad and deeply impressed behind the eyes, the pronotum is shallowly sulcate, and the dorsum of the elytra is almost flat anteriorly.

## Subfamily Cryptorrhynchinae.

**Tylodes vellericollis,** sp. n. (fig. 1).

♂♀. Derm black ; the pronotum with fairly dense erect red-brown scales ; the elytra with less dense isabelline scaling, interrupted by rows of bare granules.

*Head* with recumbent oblong scales on the vertex and erect ones on the frons, which has a deep short median furrow. *Rostrum* almost parallel-sided, but shallowly sinuate laterally around the insertion of the antennae ; the dorsum in ♀ with erect scales in the basal third, but bare anteriorly and with rather large shallow punctures ; more rugosely punctate in ♂, with a rudimentary median carina, and squamose throughout, the erect scales being longest at the apex. *Prothorax* about as long as broad, strongly rounded at the sides, widest at the middle, and shallowly constricted near the apex ; the dorsum with coarse subreticulate punctures and a fine abbreviated median carina, the punctures being almost entirely concealed by the short erect peg-like scales (which give a rather velvety appearance to the naked eye), those in the punctures being rather longer and stouter than the others ; on the pleurae the scales are less dense and recumbent or subrecumbent. *Elytra* ovate, widest before the middle and rather sharply acuminate behind, not laterally constricted near the apex, and with a deep transverse impression close to the base ; the striae with coarse punctures partly obscured by scaling ; the intervals slightly convex, and each with a row of low opaque granules (shiny at the apex on interval 1 only) bearing long erect flattened setae ; the scales all recumbent. *Legs* fairly densely squamose, the scales on the tibiae being erect or suberect ; the femora rather deeply sinuate on the lower edge near the apex.

*Length*, 6·0–7·5 mm. ; breadth 2·7–3·6 mm.

Brazil : Bahia, 3 ♂♂, 2 ♀♀ (*Dr. G. Bondar*).

The adults were found feeding on the leaves of cacao trees.

Fig. 1. *Tylodes vellericollis*, sp. n.

The species is most nearly related to *T. insubidus*, Boh., but is a much smaller insect and may be distinguished from all the previously described species of the genus by the dense clothing of erect scales and the complete absence of granules on the pronotum.

**Conotrachelus curvicostatus,** sp. n. (fig. 2).

♂♀. Derm red-brown, with sparse narrow fulvous scales ; the pronotum with a very indefinite stripe on each side formed of closer transverse scales and a small patch of dense scales in the posterior lateral angles (sometimes whitish) ; the elytra with the scaling sparse and uneven, somewhat macular in appearance, with a small denser patch at the base of interval 6, a still smaller one at the base of 3, and irregular denser scaling near the apex.

*Head* with separate punctures on the vertex, these becoming much larger and more or less confluent in front, the setae being sparse and mostly grey ; the frons as wide as the base of the rostrum, with denser fulvous scales and a large deep median fovea ; the eyes not covered by the postocular lobes in repose. *Rostrum* of ♂ about as long as the pronotum, distinctly curved, moderately stout, somewhat compressed, and 5-carinate from the base almost to the antennae, which are inserted at one-fourth

from the apex; rostrum of ♀ much more slender, straight, narrowing from the base to one-fourth and thence subcylindrical, smooth, shiny and finely punctate, except in the basal third which is 5-carinate, the antennae being inserted at three-eighths from the apex. *Antennae* with joint 1 of the funicle a little longer than 2, 3 longer than broad, 4 as long as broad, and 5–7 transverse. *Prothorax* a little broader than long, rounded at the sides, widest about the middle, rapidly narrowing in front, and with a rather shallow subapical constriction; the dorsum coarsely and closely punctate, the punctures being transversely subconfluent, and with an obtuse median carina in the anterior half; the basal margin strongly bisinuate. *Scutellum* small, longer than broad, squamose. *Elytra* subtriangular, markedly bisinuate at the base, one-third broader at the subrectangular shoulders than the base of the prothorax, and

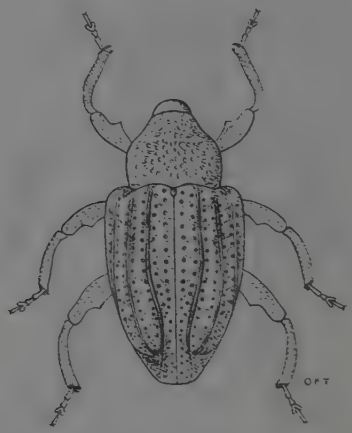


Fig. 2. *Conotrachelus curvicostatus*, sp. n.

gradually narrowing from behind the shoulders to the apex; the punctures coarse and shallow, the contained seta being inconspicuous, and the first row coalescing with the second on the upper half of the declivity; intervals 3, 5, 7, 9 sharply carinate throughout, and int. 10 carinate for a short distance near the base only; the carina on int. 3, which is higher than the others, is interrupted for a short distance at about one-fourth from the base, and at the top of the declivity it curves strongly inwards towards the suture, curving outwards again posteriorly, so that at the greatest curvature the distance between int. 3 and the suture is less than half that between ints. 3 and 5 (2 : 5). *Legs* coarsely punctate, with sparse narrow pale setae, which are rather denser and more fulvous on the apical half of the posterior pairs of femora; the femora with a single small triangular tooth; the front tibiae not dilated externally at the apex. *Sternum*: the anterior coxae contiguous; the mesosternum flattened between the coxae and truncate in front.

*Length*, 5·4–6·0 mm.; breadth, 2·7–3·0 mm.

Brazil: Bahia, 4 ♀♀ (*Dr. G. Bondar*–type); Rio de Janeiro, 1 ♂, 1 ♀ (*A. Fry*); Espirito Santo, 1 ♀ (*Descourtils*). French Guiana: 1 ♂.

The adults were found by Dr. Bondar feeding on the leaves of cacao.

# NEW SPECIES AND HOST RECORDS OF BRACONIDAE.

By D. S. Wilkinson,

*Senior Assistant, Imperial Bureau of Entomology.*

**Ipobracon peronatus,** Cam.

*Iphiaulax peronatus*, Cameron, Biol. Cent.-Amer., Hym., i, 1887, p. 337.

Trinidad: 3 ♀♀, 25.xi.1928, 5.xii.1928, 21.ii.1929 (*J. G. Myers*).

*Host.* Dr. Myers considers this parasite to be associated with the Cerambycid beetle, *Stirastoma depressum*, L., infesting cacao logs.

These specimens agree absolutely with the type (which is in the British Museum) with the possible exception that they appear to have the 2nd cubital cell relatively somewhat longer; this difference, however, is so minute that it is a character upon which I am not prepared to describe a new species.

*Ipobracon peronatus* is easily separable from the two other recorded Braconine parasites of *Stirastoma*, as follows: From *Cyanopterus depressi*, Vier., by the thorax and legs, the colour of which in this latter species is black throughout; and from *Cyanopterus steirastomae*, Vier., by the nature of the 2nd tergite, which from Viereck's description would appear to be fine and smooth.

**Rhaconotus oryzae,** sp. n.

♀. Dark red, tinged with blackish red, the head capsule and legs paler; ovipositor bright red, apparently black at extreme apex; sheaths black; apical joint of all tarsi sometimes nigrescent or black; preapical tarsal joint or joints never darkened; wings with costal vein pale red testaceous, remaining veins red-brown except towards the base where they are pale; stigma very pale to almost colourless, as is the metacarp; wings hyaline except for a very slight general infuscation.

♀. All integument coriaceous and with strong pubescence. *Head*: antennae not longer than the combined lengths of the head, thorax, and abdomen; flagellar joints 28–29. *Thorax*: notauli anteriorly strongly marked, posteriorly converging into a median, definitely somewhat sunken area; scutellar depression broad but not deep, crenulate; propodeon with at least three longitudinal carinae in basal half, one being in the middle, the others at the sides, these carinae becoming lost amongst the wrinkles with which the apical half of the propodeon abounds; basal half of propodeon devoid of wrinkles except possibly at the sides. *Wings*: recurrent interstitial or just received into the 2nd cubital cell; nervulus postfurcal by almost its own length; radial cell reaching apex of wing; stigma sub-lanceolate; 2nd abscissa of the radial vein three times, and the 3rd abscissa five times, as long as the 1st abscissa; 2nd abscissa of radial in the neighbourhood of 0·36 mm. long; radial emitted from middle of stigma; 2nd transverse cubital very faint. *Legs*: all femora with a noticeable tumescence on the anterodorsal surface at apex of basal third; the four front tibiae anteriorly with a row of minute spines. *Abdomen*: 1st and 2nd tergites completely longitudinally carinate; 3rd and 4th tergites carinate* except medianly in the apical half or third where the integument is smooth or only faintly coriaceous; 5th tergite strongly coriaceous, not carinate except possibly at the sides; 2nd–4th sutures crenulate; 1st tergite longer than broad; 2nd tergite transverse; 2nd suture virtually straight; 3rd and 4th tergites transverse, shorter,

* The strength of the carination on the 3rd and 4th tergites is very variable, occasionally being almost obsolete.

but not noticeably, than the 5th; ovipositor sheaths long, extending beyond apex of abdomen for 1·5 mm., which length is less than the combined lengths of the 2nd, 3rd, 4th, and 5th tergites.

*Length*, 4·0–4·5 mm.

INDIA: the Punjab, 6 ♀♀, 16.ii.1929 (*D. H. Khan* and *A. Singh*).

*Type* deposited in the British Museum.

*Host.* The specimens are recorded by Mr. Afzal Husain to have been bred out of borers hibernating in rice stubble. Mr. Husain forwarded to us at the same time some Chalcids definitely labelled as egg parasites of the rice borer, the Pyralid, *Schoenobius incertellus*, Wlk. (= *bipunctifer*, Wlk.), a species known to hibernate in rice stubble; it would appear, therefore, that the larvae of this moth might well have been the host of the Braconid.

*Rhaconotus oryzae* is immediately separable from the Palaearctic species of the genus by the uniformly pale stigma and the hyaline wings, from *R. sudanensis* by the straight 2nd suture and the length of the ovipositor, and from *R. scirpophagae* by the straight 2nd suture and the number of flagellar joints.

**Microplitis radicalis,** sp. n.

♀♂. Black; mouth parts, prothorax, mesothorax including scutellum, tegulae, the front legs completely, the 1st, 2nd, and 3rd abdominal segments (except the chitinised tergal plates), red or red testaceous; the middle tibiae and tarsi, and often portions of the middle femora, strongly reddened; tibial spurs pale; stigma and wing veins black or dark brown; wings infumated, in the ♂♂ more or less generally, in the ♀♀ with the two basal cells of the fore wing, and in the hind wing with the anal and 2nd basal cells almost completely, and the apical half of the 1st basal cell, and the discoidal cell basally, more or less hyaline; in the fore wings of both sexes the upper basal half of the 1st cubital cell is more or less hyaline, while the whole apical half of this cell, together with the 2nd cubital and a small area at the base of the radial cell, is usually rather more strongly infumated than other parts of the wing.

♀♂. *Head* with extremely close minute punctation which gives to the face almost a rugose appearance; facial depressions large and deep, rather nearer to eyes than to apex of clypeus; clypeus apparently without basal suture; hind ocelli possibly rather nearer to each other than to the eyes. *Thorax*: mesonotum minutely punctate, with broad, shallow, but definitely marked, notauli which converge into a broad flat, extremely shallow, median, posterior area; mesopleural sulcus large, strongly crenulate; scutellar sulcus broad, deep, divided into four foveae; disc of scutellum with a weak median longitudinal carina, some transverse carinae, and strongly margined along the sides; propodeon coarsely and strongly reticulate and with a strong median longitudinal carina, the basal two-fifths virtually at right-angles with the more or less perpendicular, somewhat excavated, apical three-fifths, the junction of these two portions not rounded but acute, thus resembling the propodeon of *M. bimaculatus*, Cam. *Legs*: hind coxae considerably shorter than 1st tergite, with minute punctation; hind tibial spurs subequal, rather longer than one-third the basal joint of the hind tarsus. *Abdomen*: 1st tergite nearly parallel-sided, progressively only slightly broader posteriorly, with length variable with regard to breadth but invariably at least twice as long as broad, with a strong, median, longitudinal excavation which does not quite reach to apex but which terminates in a strong, somewhat elongate, median tubercle; remaining tergites smooth and shining; 2nd suture very fine; ovipositor sheaths short, without process.

*Length*, 5–6 mm.

CHINA: 4 ♀♀, 6♂♂, 25–29.v.1912, and undated specimens (*R. Meli*).

*Type* in the Zoological Museum, Berlin.

*Host* unknown, possibly the larva of a Sphingid moth.

*Cocoons.* There is one cocoon with this series, 8 mm. long, and typical of the genus.

This species, on account of its colouration, is much like *basalis*, Bingh., but is immediately separable therefrom by its margined scutellum; from *bimaculatus*, Cam., another related species, it differs, apart from colouration, notably in the nature of the notauli, these in Cameron's species being exceptionally strong and strongly crenulate.

**Microdus aciculatus,** Brues.

*Bassus* (*Microdus*) *aciculatus*, Brues, Proc. American Acad. Arts and Sci., lxi, 1926, p. 285.

UGANDA: Kampala, 4 ♀♀, 9 ♂♂, 2.iii.1928, 7–24.i.1929, 23–28.ii.1929, 6–13.iii.1929 (*G. L. R. Hancock*).

*Host.* Recorded by Mr. Hancock as bred from the cotton boll-worms, *Earias biplaga*, Wlk., and *E. insulana*, Boisd.

I have compared the present series with the type, which is in the British Museum. It is a species that exhibits considerable variation both in colour and sculpture. In the propodeon of some forms the "elongate median area" is remarkably well-formed, in others virtually lost amongst the rugosity of this part. The mesopleural sulcus varies between strongly crenulate and entirely smooth, and is commonly marked as a succession of strong punctures. Antennae with 28–30 joints in ♀, and 28–33 joints in ♂. The colouring of the ♂♂ normally differs remarkably from that of the ♀♀, but I have one or two specimens that virtually agree with the ♀♀ in this respect. In the ♂♂ the apical tergites are invariably black, or darkened to some extent; the head and thorax (except propodeon) commonly black; often with the propodeon strongly darkened at base discally; sometimes with only the mesonotum and propleurae black. The ♂♂ otherwise, and the 4 ♀♀ before me, agree in colour with the description of the type, except that the wings in my opinion would be more correctly described as strongly, rather than "slightly" infuscated, and that the hind tibiae are more usually, but not invariably, black in the apical sixth.

This species was described by Brues from a single female.

**Dinocampus mylloceri,** sp. n.

♀♂. Red or red testaceous; ocelli, tips of mandibles, metanotum, propodeon discally, ovipositor sheaths, strongly darkened to black; flagellum largely brown; stigma hyaline, bordered with brown; wing veins brown.

♀♂. *Head*: face and frons finely rugose, opaque; vertex and occiput indefinitely punctate, shining; flagellum with 26–27 joints; ocelli decidedly nearer to each other than to the eyes. *Thorax*: mesonotum punctate, but rather indefinitely; the distinctly impressed, crenulate, regularly converging notauli join at a point immediately anterior to the scutellar depression, the median area of the mesonotum rugose posteriorly; scutellar depression broad, deep, and crenulate; disc of scutellum minutely punctate; propodeon strongly reticulate, the posterior portion perpendicular and evenly rounding off with the somewhat shorter, horizontal, anterior portion; the posterior portion with a strong, broad, median, longitudinal excavation which

extends, but only weakly, into the anterior portion to the extreme base of the propodeon. *Wings* (fig. 1) : apex of metacarp and of the 2nd abscissa of the radial)

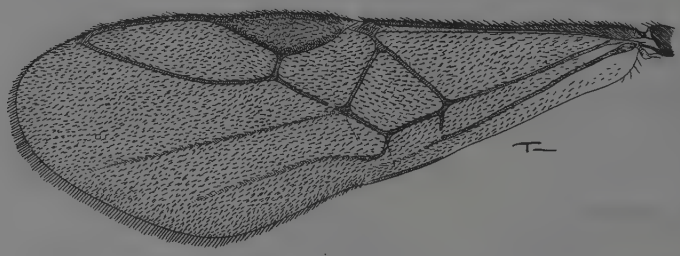


Fig. 1. *Dinocampus mylloceri*, sp. n., forewing.

at a point definitely nearer to the apex of the wing than to the apex of the stigma. *Abdomen* : 1st tergite strongly longitudinally striate in apical half, its spiracular protuberances inconspicuous ; succeeding tergites entirely smooth and shining ; 2nd suture not apparent ; ovipositor sheaths rather longer than the 1st tergite, about as long as the abdomen without the 1st tergite.

*Length*, 3 mm.

India : Pusa, Bihar, 3 ♀♀, 1 ♂, xii.1927 (*type*), 15.xii.1926, 2.iii.1928 (*G. R. Dutt*).

*Type* deposited in the British Museum.

*Host.* Bred from adults of the weevil, *Myllocerus maculosus*, Desb., a pest of cotton.

*Cocoons*, white.

*D. mylloceri* differs from the common species, *D. rutilus*, also a parasite of Curculionidae, to which it is obviously closely allied, notably in having the ovipositor sheaths relatively rather shorter, the propodeon decidedly more coarsely sculptured, and the head broader and more strongly transverse.

Mr. Kidar Nath Trehan, in a paper on the life-history and bionomics of *Myllocerus maculosus*, gives a few notes with regard to, and illustrates, the larva, pupa, and cocoon of *D. mylloceri* (Agric. Research Institute, Pusa, Bull. No. 181, 1928 (1929), pp. 25, 26, and Plate V). He also gives a greatly enlarged drawing of the adult Braconid ; unfortunately this drawing is misleading since the venational characters are far from accurate, and since the notauli are made not to join posteriorly. The Braconid was also wrongly identified for the author, and referred to by him in his paper, as a new species of *Loxocephalus*.

# THE SUDAN MILLET BUG, *AGONOSCELIS VERSICOLOR*, F.

By F. G. Sarel-Whitfield,

*Assistant Entomologist, Sudan Government.*

(Plate XI.)

## Introduction.

The Sudan dura (millet) bug, *Agonoscelis versicolor*, F., a member of the family Pentatomidae, Hemiptera Heteroptera (Rhynchota), is an important pest of millet. Its depredations vary from year to year, depending chiefly upon the rainy season, but every few years it causes serious losses of millet (*Sorghum vulgare* and *Sorghum* sp.), which is the main food crop of the Northern Sudan.

This bug is widely distributed in Africa, but so far as the writer is aware, it is only in the Sudan that it occurs as a serious pest of grain, or, indeed, as a serious pest at all. In view of this, and the little work that has been done upon it, it was felt advisable, when a severe outbreak took place in 1927, not only to concentrate upon the control but also to effect as complete a study as possible of the bionomics and essential morphology of the bug.

Upon completion of the work it was found better to publish the results as two separate papers: (1) A Sudan Government Entomological Bulletin,* giving an account of the bug as a pest in the Sudan, the control measures carried out, the bionomics and parasites; and (2) a paper for publication in a scientific journal giving the results of the morphological studies, and their relation and application to the bionomics of the insect. The present paper is the result of the latter study.

## Geographical Distribution.

*Agonoscelis versicolor*, F., has been recorded from all over the African continent; the following list of localities, though not complete from the point of view of local distribution, yet gives an idea of its range:—

The Sudan, from Khartoum southwards, Uganda, Kenya Colony, Nyasaland, Northern Rhodesia, Southern Rhodesia, Transvaal, Natal, Cape Province, Angola, Gold Coast, Cape Verde Islands, and Madagascar.

## Economic Importance.

This bug has been reported on no less than ten occasions within the last twenty years, that is up to 1927, as causing damage to the dura crop of the Sudan, and in 1909 it was noted as attacking sunflower heads. As early as 1906, the Government Entomologist, Mr. H. H. King, recorded the bug as a pest of dura, and this constitutes the first authentic occurrence of the insect as a pest in the Sudan.

It is specially troublesome in heavy rain years following a summer and winter in which the conditions of humidity have been favourable to the resting bug. In the years when it does not occur as a pest, it nevertheless causes trouble in small areas, and in bad years it is often the direct cause of local famine. The older natives speak of the insect as recurring at long intervals and causing great damage. In the earlier accounts the bug was erroneously recorded as *A. puberula*, Stål, but in every case the species was actually *A. versicolor*.

* Sudan Government Entomological Bulletin no. 28; to be published later.

The adult insect, and occasionally the final nymphal instar, feeds only upon the millet grains, and in view of the fact that the damage done is so considerable (figs. 1 and 2), it is worth while studying the cause and effect. In feeding, only the stylets pierce the plant, the labium acting merely as a sheath, or grip for the former. The resultant puncture in the epidermis of the leaf or grain is microscopic, yet after a bug has punctured and fed upon a dura grain, if only for a few moments, the latter becomes atrophied and all further development ceases. The bugs attack the grain

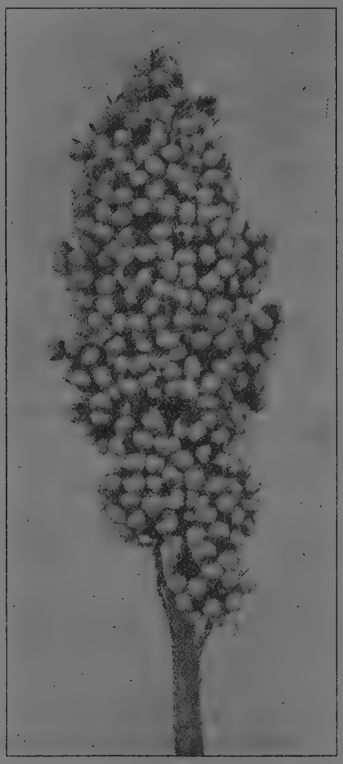


Fig. 1. Normal head of millet.

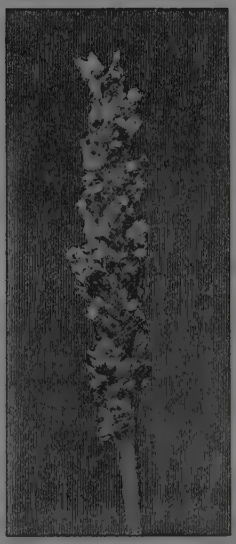


Fig. 2. Head of millet after attack by *Agonoscelis versicolor*.

when it is in the soft stage, prior to final ripening, and thus are easily able to pierce it. In common with most of the Hemiptera they inject a copious quantity of saliva, which undoubtedly acts as a powerful anticoagulin and, in the case of the young grain, apparently as a definite poison as well. This is not surprising when consideration is taken of the delicate nature of the half-ripe grain, but the effect is not so apparent when the stem or the petioles of the weeds upon which the bugs breed are the objects of its attack; these probably offer a much more powerful resistance. The fact that the attack of the bug is so fatal to the young grain is the chief factor in the great amount of damage done, as the bugs frequently move from grain to grain, taking a sip at each and leaving behind them a train of ruined fruit.

## Description and Morphology.

*Agonoscelis versicolor* is a typical Pentatomid in shape, the scutellum being moderately developed. The upper surface is fulvous brown, with variable, deeply rugose, dark patches that form a rough pattern and cause much of the colour variation, which ranges in depth of tone from very dark brown to light umber. When clustering upon a tree the insect merges well into its background; but in flight it is fairly conspicuous, owing to the membranes of the hemelytra bearing black patches at their bases that vary in density and extent (fig. 3), the hind wings also having a variable

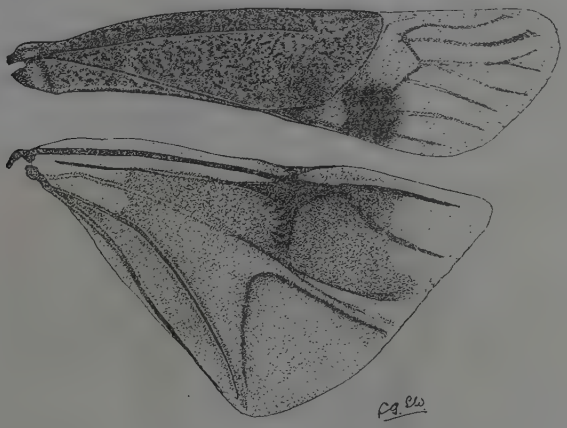


Fig. 3. *Agonoscelis versicolor*, hemelytron and wing.

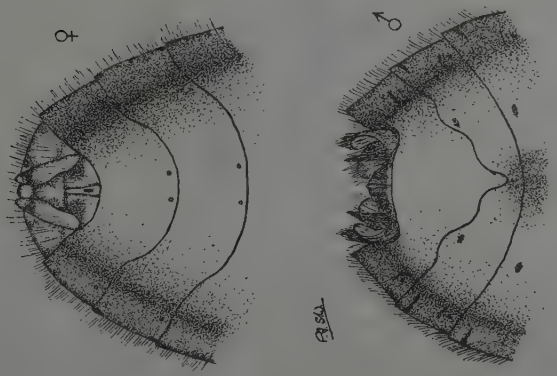



Fig. 4. *Agonoscelis versicolor*, apex of sternum, showing sexual differences.

darkened area, and the dorsal surface of the abdomen being a bright brick-red. The insect is covered with a thin light-coloured pubescence, which is only apparent upon close examination. The ventral surface of the abdomen bears four roughly parallel rows of small black patches, but these are often reduced to rudimentary marginal spots on each side, or are even entirely absent. Field recognition of the

sexes is an easy matter (fig. 4), the sternites differing widely in shape and convolution, and the gonapophyses being equally distinct.

*Mouthparts.*—The mouth-parts differ in no way from the normal type of Heteropterous trophi, but the salivary glands are highly developed even for the Hemiptera. Trilobed, with filiform accessory glands, they lie medianly in the thorax, extending almost into the abdomen (fig. 5). In some cases the main gland would seem to be

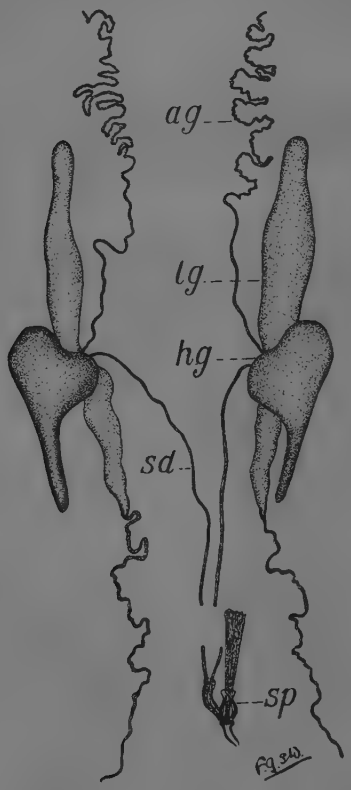



Fig. 5. *Agonoscelis versicolor*, mouth parts: *ag*, accessory gland; *hg*, heart-shaped gland; *lg*, long gland; *sd*, salivary duct; *sp*, salivary pump.

only bilobed, but in the majority of specimens examined the ventral portion of the gland definitely appeared to be segmented, thus forming a trilobed gland. The main gland lies in two planes, the two ventral lobes lying parallel and close to the large anterior chamber of the mid intestine, with the third lobe immediately dorsad of them. The ventral lobes are distinctly lighter in texture and more membranous than the upper one and elongate tubular in shape; the superior lobe is retort-shaped, being prolonged anteriorly into a kind of thick horn, and is distinctly heavier in structure and opaque. The filiform accessory glands lie on each side of the anterior chamber of the mid intestine, to which they are firmly attached by a network of tracheae. As is usual with the Hemiptera, the main salivary duct of each gland

opens at the junction of the three lobes, the accessory gland entering the salivary duct just above the anastomosis of the lobes of the main gland. The two salivary ducts do not unite but enter separately into a common short membranous chamber attached ventrally to the salivary pump.

*The Alimentary Canal.*—The alimentary canal (fig. 6) from the pharyngeal duct

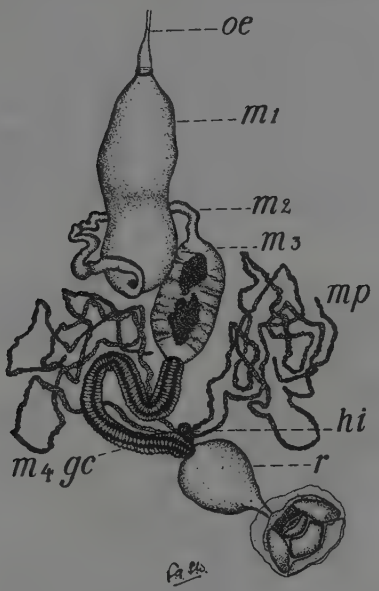



Fig. 6. *Agonoscelis versicolor*, alimentary canal: *oe*, oesophagus; *m1*, *m2*, *m3*, mid intestine, 1st, 2nd, and 3rd chambers; *m4gc*, mid intestine, 4th chamber, with gastric caeca; *mp*, malpighian tubes; *r*, rectum.

to the oesophagus is of normal structure, the usual gustatory organs being present and communicating with the lumen of the pharynx. The remainder of the digestive tract, while following normal Heteropterous lines, yet presents certain features of interest. It consists of the mid-intestine, which is composed of four chambers, the hind intestine, and the rectum. The first or anterior chamber, when fully developed, consists of a large sac lying in and occupying the whole of the thorax and part of the abdomen; the second chamber is elongated into a thick sinuous tube, which, opening slightly dorsal from the posterior apex of the first chamber, curls beneath the latter towards the left (viewed dorsally) and opens into the third chamber, also of sac-like structure, but about half the size of the first; the third chamber lies usually slightly to the right of the main line of the digestive tract and may vary in being either slightly dorsad or ventrad to it; the fourth chamber is similar to the second, though slightly shorter and thicker, and is densely covered with short, tubular, tightly packed gastric caeca, which are probably filled with the usual symbiotic bacteria, though on this point the writer has not had sufficient time for a close examination. The hind intestine is unusually small and lies ventrad to the fourth chamber of the mid intestine and opens with it into the rectum; the hind intestine possesses four elongated vermiform malpighian tubes, two on either side, which are coiled in the hind body cavity. The rectum is a normal sac-like structure.

The development of the alimentary canal is unusual, in that, owing to the bug spending ten months of the year in a resting state between two short periods of activity, the canal varies considerably in size and shape during the life-time of the insect. When the young bugs have been hatched, they develop rapidly and upon reaching the adult stage continue to feed until pairing is finished, when they forsake the now rapidly drying vegetation and grain for the comparative shelter of such trees and shrubs as are available. Meanwhile the alimentary canal has reached its normal development, and upon dissection at this stage, will be found to occupy almost the whole of the body cavity. During the subsequent long period of total inactivity no food whatsoever is taken by the insect, with the result that during the latter half of the resting period the alimentary canal is considerably reduced in size, the first and third chambers of the mid intestine, which appear to be used as storage chambers, having shrunk to at least half their full size, and being often much smaller still. When, upon the approach of the rainy season, the bugs leave the trees and start to feed again, the alimentary canal once more becomes greatly enlarged and remains so until the act of copulation.

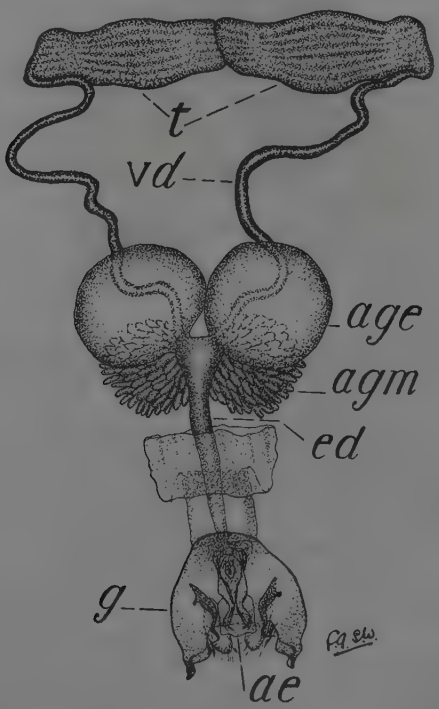



Fig. 7. *Agonoscelis versicolor*, male reproductive organs: *ae*, aedoeagus; *age*, accessory gland ectodenes; *agm*, accessory gland mesadenes; *ed*, ejaculatory duct; *g*, gonapophyses; *t*, testis; *vd*, vas deferens.

*The Reproductive Organs.*—The male reproductive organs (fig. 7) consist of a pair of testes attached by vasa deferentia to a chamber which may be a common vesicula seminalis, but appears more probably to be of ectodermal origin; there are two pairs

of accessory glands, probably mesadenes and ectodenes, an ejaculatory duct, and a highly extensible aedoeagus. The testes consist each of six follicles enclosed in a large, strongly pigmented scrotum, dark red in colour and slightly corrugated on the surface ; and the vasa deferentia are long and thick. So large are the testes that frequently they lie with the extremity of one resting upon the other (fig. 5). In the accessory glands, the mesadenes consist of paired bunches of small tightly packed egg-shaped glands, in appearance similar to a *Calliphora* ovary ; immediately dorsad of these are the ectodenes, which are in the form of semi-transparent spherical sacs. The ejaculatory duct opens into a large, highly extensible aedoeagus, which with the gonapophyses forms a large " penis " easily extrusable under pressure when handling the insect.

The female reproductive organs (fig. 8) consist of paired ovaries, oviducts, vagina, a possible bursa copulatrix, and a spermatheca. The ovaries are composed of seven ovarioles each, probably acrotrophic, opening *via* normal oviducts into a median vagina which merges directly into a bursa copulatrix, though some morphologists might consider the latter to be absent. A highly developed spermatheca, or receptacu-

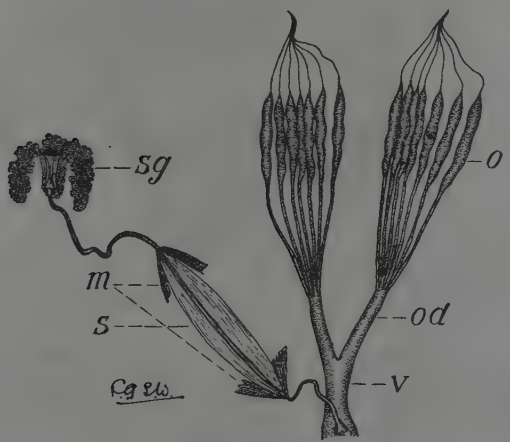



Fig. 8. *Agonoscelis versicolor*, female reproductive organs : *o*, ovarioles ; *od*, oviducts ; *s*, spermatheca ; *m*, muscular cover ; *sg*, spermathecal gland ; *v*, vagina.

lum seminis, is present, opening dorsally into the bursa copulatrix ; it is elongated and surrounded by epithelium, which in turn is covered by a thick muscular layer. In cleared specimens it has the appearance of a chitinous rod. A trilobed gland delivers into a cylindrical chamber or valve surrounded by a membrane and a muscular sleeve, which delivers by means of a long tube into the spermatheca, which is in turn attached to the bursa copulatrix by means of a somewhat shorter tube.

Apart from purely morphological characteristics, the reproductive organs exhibit more than usual interest in their development. The male organs pursue a normal course and are fully developed before the insects settle down to their long rest ; they are, moreover, of unusual size, being considerably larger than those of the female. The latter mature very much later and undoubtedly are an important determining factor with regard to the final movements of the bug when about to leave the resting quarters at the coming of the rains. The spermatheca, curiously enough, is developed early ; and though in some females that oviposit before the resting period, thus forming an occasional extra brood, the ovaries are also developed early, the majority

of the later hatched females do not oviposit until some ten months afterwards, and it is not until towards the very end of this period that the ovaries begin to mature. Actually, whether the final development is spontaeous, or whether it rests with the primary coitus to set the ball rolling, is as yet imperfectly understood, but it would seem, in view of the peculiar reactions of the insect to climatic conditions, that the former might conceivably be the case.

*Repugnatorial or Odoriferous Glands.*—In common with the majority of Pentatomidae, *A. versicolor* possesses a single sac-like gland, situated ventrally in the thorax, and opening by means of chitinous ducts into a pair of slit-like orifices on

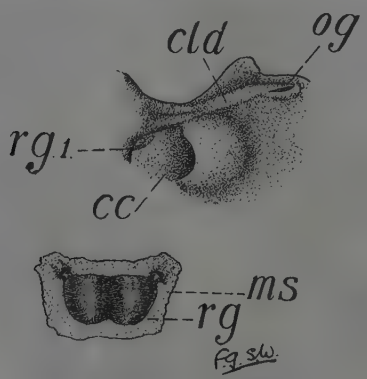



Fig. 9. *Agonoscelis versicolor*, repugnatorial gland: *cc*, coxal cavity; *cld*, chitinous duct; *og*, orifice; *ms*, integument of metasternum; *rg*, the gland; *rg1*, pigmentation of the gland showing through the coxal cavity.

either side of the hind coxae. The gland itself (fig. 9) is a round sac-like organ of the same colour as the dorsal surface of the abdomen, *i.e.*, brick-red. So powerful is the secretion that the insect has few predatory enemies that will face the odour.

## Life-history: Early Stages.

The development from the egg to the final instar takes place within a period of 18 to 29 days and is complete before the dry weather advances.

During August, after a certain amount of rain has fallen, the adult bugs leave their resting quarters in trees, hedges, etc., and fly off in search of food. They usually select "berseem" (lucerne—*Medicago sativa*, L.) and a variety of indigenous weeds, such as "um galot" (*Leucas urticifolia*, Benth.), "dokhan el azabat" (*Heliotropium* sp.) and "rehan" (*Ocimum basilicum*, L.). Breeding soon commences, and during the last week in August well-arranged clusters of typical barrel-shaped Pentatomid eggs are laid, either on the lower surface of the leaves, on the inflorescences, or on the stalks of various weeds, while they are sometimes to be found on the ground or on débris underneath the plants. There is a wide choice of situation, but in all probability a little shade is desirable. When reared in the insectary, eggs were commonly found on the muslin and wooden frame-work of the cages. The number of eggs in a cluster varies considerably, as many as 63 having been counted; the usual number, however, is about 30. Natural fertility is, as a rule, high, but during 1928 in particular, very many eggs were found to be parasitised. The incubation period is 3–5 days, after

which the young nymph emerges by prizing open the operculum by means of the T-shaped denticle or egg-burster. The denticle is shed as soon as it has fulfilled its purpose, and is usually to be found attached to the empty chorion.

There are five nymphal instars (figs. 10–14) before the adult instar is reached, and, as is usual in among bugs of this family, there are great differences in colour and

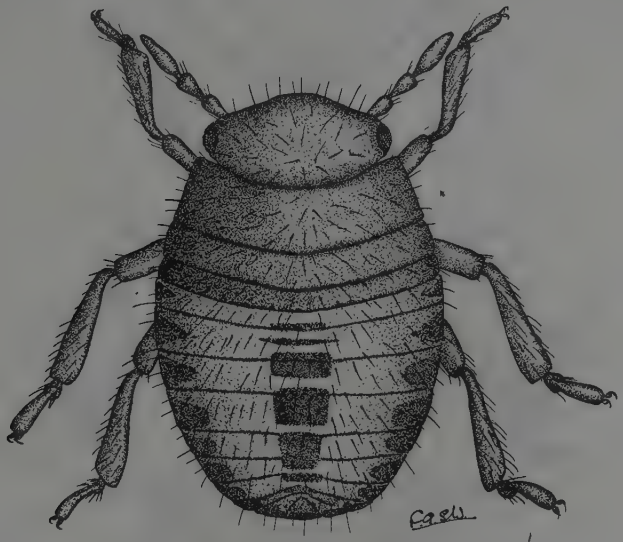


Fig. 10. *Agonoscelis versicolor*, 1st instar (natural size, 3 mm.).

Fig. 11. *Agonoscelis versicolor*, 2nd instar (natural size, 6 mm.).

ornamentation between the nymphs of the different stages. Variations even occur in nymphs of the same instar. In the field most of the specimens exhibit fewer dark markings than many of those which have been reared in the insectary. The length

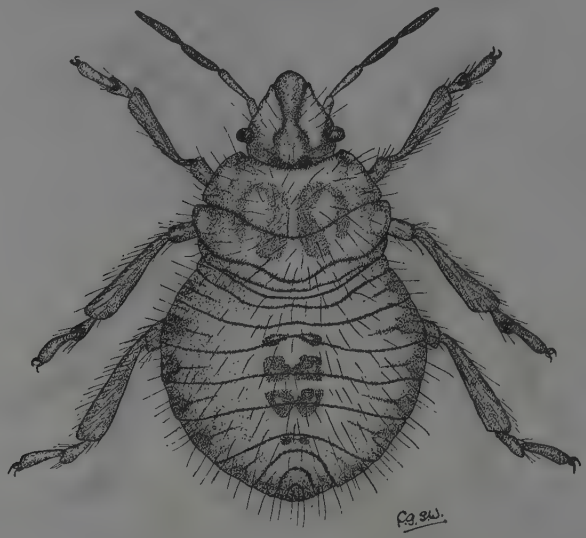


Fig. 12. *Agonoscelis versicolor*, 3rd instar (natural size, 4 mm.).

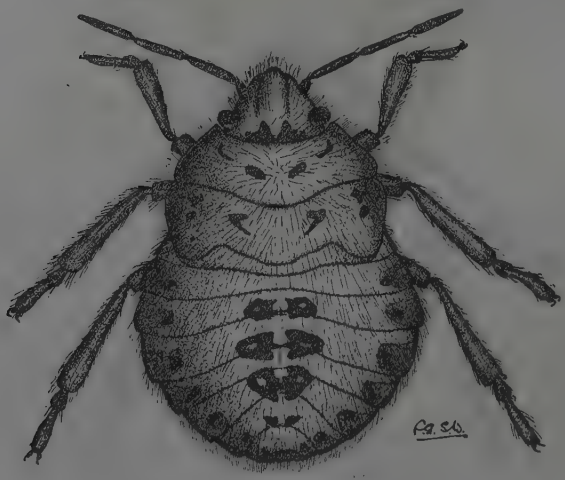


Fig. 13. *Agonoscelis versicolor*, 4th instar (natural size, 7 mm.).

of the life-cycle, from egg to adult, is 18–29 days, but 22 days is the commonest period required. The duration of the early stages may be summarised as follows :—

| | | | |
|---|---|---|---|
| Egg stage | 3–5 days ; | average, | 3·5 days. |
| 1st instar | 2–3 ,, | ,, | 2·25 ,, |
| 2nd ,, | 2–4 ,, | | 3·0 ,, |
| 3rd ,, | 3–4 ,, | ,, | 3·5 ,, |
| 4th ,, | 4–6 ,, | ,, | 4·25 ,, |
| 5th ,, | 4–7 ,, | ,, | 5·5 ,, |
| Total | 18–29 days ; | average | 22 days. |

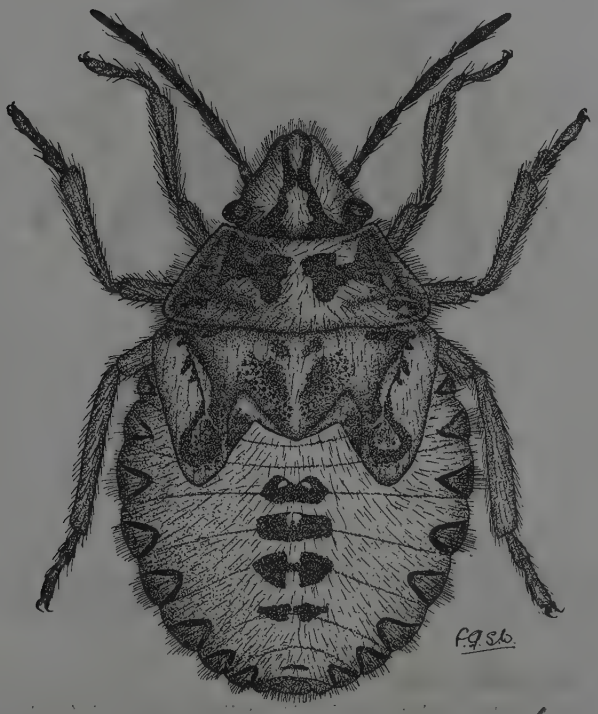


Fig. 14. *Agonoscelis versicolor*, 5th instar (natural size, 16 mm.).

The habits of the nymphs vary slightly. The earlier nymphs keep together more or less and show a preference for the flower-buds and fruit-capsules of *Heliotropium* and *Leucas* ; whereas the more mature nymphs tend to wander from plant to plant, especially if disturbed in any way, and are generally found feeding on the drying capsules and seeds of *Leucas* and *Ocimum*, often only one or two on a single plant. *Leucas* is usually preferred to *Ocimum* by the nymphs, but the young adults occur commonly on both plants.

On reaching maturity, the adult bugs (fig. 15) feed for a few days on their various weed food-plants before they fly off to attack the ripening heads of dura (*Sorghum vulgare*).* As a rule, there is only one generation per annum, but it is possible that

Fig. 15. *Agonoscelis versicolor*, adult ♂ (natural size, ~~22~~ 12 mm.).

a second may take place in certain circumstances. After their attack on dura, the bugs migrate about the end of October to trees and bushes, and there, in clusters, enter upon their resting stage.

**Life-history : the Resting Period.**

An important feature in the life-history of this insect is the long resting period during the adult stage. This occupies no less than nine months, throughout which time no food of any sort is taken, and very little movement evinced ; in fact, in suitable situations the bugs will remain motionless throughout nearly the entire period.

Certain meteorological conditions are essential for the well-being of the insect during this time. Primarily a tree affording plenty of shelter from sun and wind, and a moderate degree of humidity, is preferred. If the shelter provided is dense, the bugs will remain motionless ; if, however, the tree selected has little or no foliage, the bugs will travel round the trunk or limb upon which they are clustered in their attempts

* Nymphs in the final instar have also been observed feeding on the grains of dura.

to keep the bulk of the tree between them and the sun. So sensitive are they to the power of the sun, that in more or less exposed situations they will frequently be found flying round their resting places during the heat of the day, only returning to settle down as the cool of the evening draws on.

Cold affects them in the opposite manner, and occasionally on very chilly mornings it is possible to brush them off the trees in clumps, which fall to the ground like so much wax and do not even disintegrate on the impact. Obviously a situation with as little variation in temperature as possible is sought after.

During the resting period in a favourable season, the mortality is very low indeed, with the exception of the last week or so, and probably not one bug in ten thousand perishes until the beginning of the rains. A certain number is destroyed by the early storms, but no enemies appear to attack them. During a very dry winter, however, the bugs probable suffer severely, and in many cases large numbers are destroyed by the lack of sufficient humidity.

*Reaction to Tropisms.*—In the reaction of *A. versicolor* to certain tropisms lies a possible clue to its development and final movements during the resting period. The bug is positively chemotropic and tactotropic, and negatively thermotropic, and these three tropisms seem to govern the insect's entire conduct during the resting period.

Once the bug has attained its chosen resting place and settled down, the rate of metabolism slows up, feeding ceases, development ceases, what nourishment is required is absorbed from the fat-body and from the first and third chambers of the hind intestine, and the tracheal system is noticeably deflated, and from now onwards the only movements occurring are due to reaction to adverse meteorological conditions. If the insect is disturbed in any way its natural reaction is not to fly, but to fall to the ground, and once there it immediately makes for the nearest tree. The word "nearest" is here used advisedly, as the judgement of distance upon the part of the bug is really remarkable. Many times did the writer experiment in this connection, but unless the bugs were dropped precisely midway between two trees, they would invariably and unerringly make for the nearer. If the day was very hot, they would fly when disturbed, and when this occurred the tropism was less marked, frequently a new tree altogether being selected. It is difficult to determine exactly what reaction is at work resulting in the accurate selection of the nearest shelter. It is most certainly not sight, as in the ordinary way the bug does not appear to possess great powers of vision; and it is possibly smell.

Tactotropism is strikingly evinced in the bug's gregarious clustering habit (Plate XI), it being exceedingly rare to find any less number than five or six clustered together, the usual number being in the region of five or six hundred. Thermotropism is shown in the reaction to undue warmth and in choice of situation.

*Maturation of the Ovaries.*—The majority of adult females that finally leave the weeds and grain-fields to fly to trees and shrubs for their long rest are sexually immature. Some there are which have already copulated, and which are therefore naturally fully developed; but whether these females survive, go to the trees and breed again the following year, is a little doubtful, and this point needs further investigation.

However, the ovaries of the majority, if examined at any time during the resting season, will be found to be almost rudimentary, and it is not until the bugs are about to move off the trees that the first sign of further development is shown. They are fully developed about ten days after leaving their resting quarters.

*Final Movements.*—If in a good situation, the bugs remain motionless until towards the end of the resting period. The first involuntary movements, other than avoiding heat, etc., are usually coincident with the first rain-storm.

In a normal year in the Blue Nile Province, the rains proper are heralded by one or two isolated storms, which, if they be not too far apart in date, cause various weeds and grasses to spring up, only to die out again before the rains start properly.

Frequently the result of these advance storms is to bring out Lepidoptera, Diptera, etc., which, like the weeds and grasses, soon disappear again. *A. versicolor* in similar circumstances behaves in a peculiar manner, for after a heavy early rainstorm the bugs leave the trees in numbers and fly about uneasily, as if not quite sure whether Kharif had really arrived: but they soon return to their resting places and settle down once more. This performance is repeated until the rains are well started, and no matter how early the original storms may occur, the bugs do not leave their resting quarters until about the 30th July. But when they do move, they move as one insect, and although on 29th July the shrubs and trees may be full of them, by 1st August not one will be left; all will be busy feeding and copulating. Their unanimity of purpose is truly remarkable and can scarcely be put down to a tropism, as the conditions involved differ greatly from year to year; some other cause must be sought. It is at this point that the peculiarly late development of the ovaries might well be suspected of playing a part, although without considerable further study any definite statement would be premature.

The following semi-diagramatic graph (fig. 16) demonstrates concisely the relation between breeding, resting and the development of the ovaries and alimentary canal of *A. versicolor*.

The top graph represents the conditions arising when the insects in question are the early progeny of bugs off the trees, *i.e.*, the adults from the earliest laid eggs. In all probability these will develop quickly and will breed immediately they are mature: they then may or may not survive, the alternatives being both illustrated. If they do survive, they go through the resting period fully developed sexually, both male and female, and probably lay a second lot of eggs the following year and then die.

In the second diagram the bugs in question are the adults from eggs laid very much later, and in this case no coitus occurs and the bugs seek their resting quarters when full-fed, the females being sexually immature. It will be noticed that in this case, in spite of the restlessness evinced during May, June and July, it is not till the end of the latter month that any determined move is made—coincident with the final development of the ovaries.

In the first case, although the ovaries are already fully developed the movement off the trees is identical with that in the latter illustration, the strong urge of the gregarious instinct probably causing the final move. It will be observed that the alimentary canal undergoes similar reduction and development in each case.

If the lower graph be superimposed upon the upper one, it will be seen that the period of egg-laying in the latter coincides with the hatching period in the former. Between these two there are, of course, many degrees, and were it not for undue complications a comprehensive diagram could be shown giving the life-history of every degree between the two examples here illustrated, and affording instances of eggs hatching throughout August and September: although normally very few nymphs would survive after the latter date as they would probably be unable to reach maturity early enough to escape the dry weather.

### *Anatomical Technique.*

The climate of the Northern Sudan does not lend itself readily to accurate laboratory technique. Unfortunately, owing to lack of facilities, no microtome work was attempted, but the normal microscopical processes provided sufficient problems in many ways. It was found that for a mountant ordinary Canada balsam was distinctly superior to anything tried. Euparal, which the writer has used to some extent in England, proved unsuitable owing to its great evaporation and to the fact

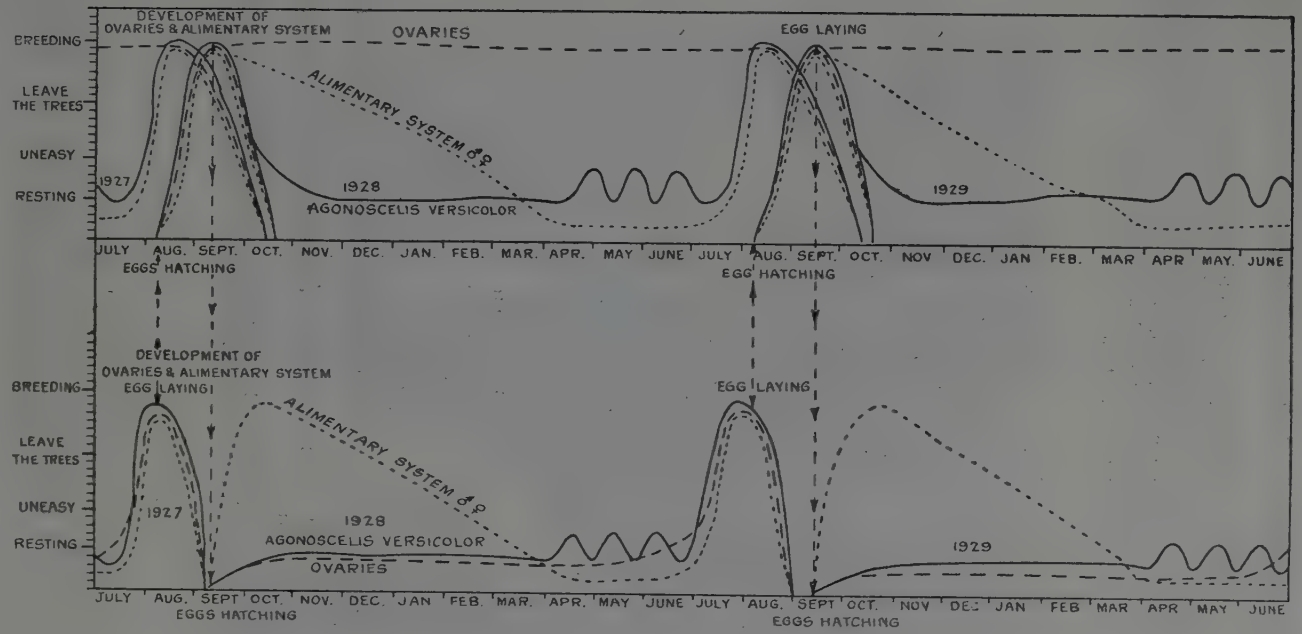



Fig. 16. Graph showing relation between breeding, resting, and development of the ovaries and alimentary canal of *Agonoscelis versicolor*.

that it is almost impossible to make satisfactory permanent preparations with it, especially without rings.

Many stains which are satisfactory in a temperate climate fade very quickly in the Sudan. The most successful stains used were acid fuchsin, orange G. and light green for chitin, and orange G. and light green for tissue; while for certain preparations in which tissue differentiation and degrees of thickness of chitin were the desired objects, a made-up stain in the following proportions was found to work excellently and to remain clear for some time.

| | |
|---|---|
| Acid fuchsin ... ... ... ... ... | 50 per cent. |
| Light green ... ... ... ... ... | 30 per cent. |
| Orange G. ... ... ... ... ... | 10 per cent. |
| Polychrome methylene blue ... ... ... | 10 per cent. |

Fixation was the most difficult process of all. The writer found that Carnoy No. 2 formula (Bolles Lee) was by far the best from every point of view, and it kept specimens in good anatomical condition very much longer than any other method; but even this was not really satisfactory. The method employed was as follows: the insect was punctured in the first abdominal segment and immersed in Carnoy 2 for twenty-four hours; it was then removed to 70 per cent. alcohol and washed in this with frequent changes for the next twelve hours, when it was finally left in a clean tube of 70 per cent. alcohol.

### *Previous References to the Habits of Agonoscelis.*

[1914]. Anderson (T. J.). Ann. Rep. Dept. Agric. Br. E. Africa 1912–13, p. 128. *A. puberula* recorded on coffee.

1916. Jack (R. W.). Rhodesia Agric. J., xiii, p. 231. *A. puberula* and *A. erosa* recorded as swarming on citrus.

1917. Anderson (T. J.). Bull. Dept. Agric. Br. E. Africa, no. 2, p. 41. *A. puberula* on coffee.

1918. King (H. H.). [Sudan Govt.] Entom. Bull. no. 8, p. 2. *A. puberula* on dura; since proved to be *A. versicolor*.

1922. Cluster Bugs. J. Dept. Agric. Un. S. Africa, v, p. 398. *Agonoscelis* spp. clustering in trees.

1924. *Ibid.*, viii, p. 358. *A. versicolor* in sunflower seed-heads.

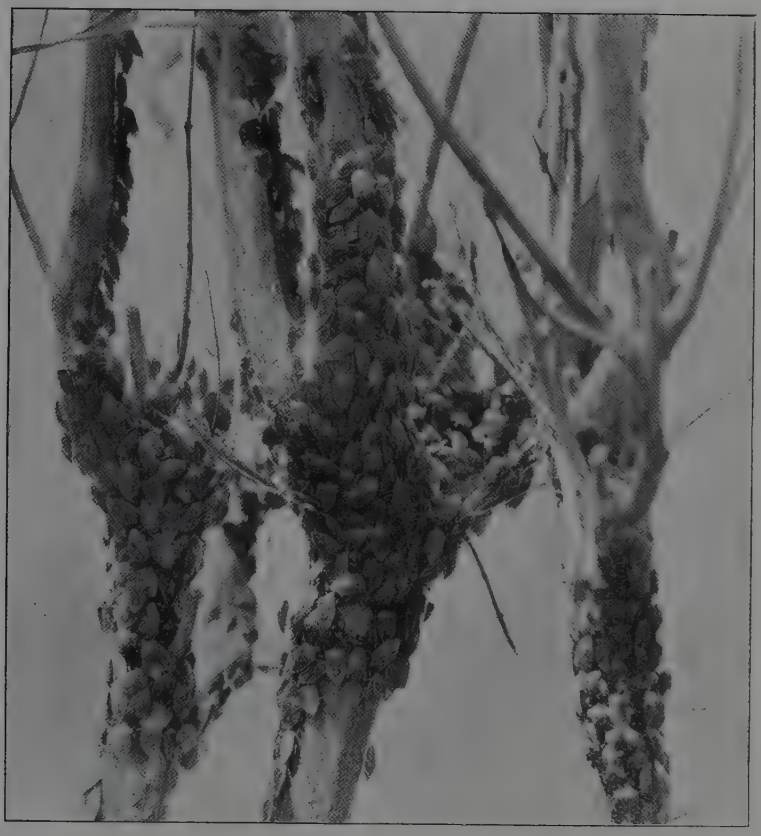
1925. *Ibid.*, x, p. 200. *A. versicolor* swarming on willow, pepper, eucalyptus, fruit trees and salt-bush.

[1925. Ritchie (A. H.).] Rep. Dept. Agric. Tanganyika Terr. 1924–25, p. 44. *A. versicolor* on cotton.

1928. The Cluster Bug again. Farming in S. Africa, Jan. 1928, reprint 2 pp. *A. versicolor* swarming on eucalypts, acacias and peach; feeding on green peaches.

### *Acknowledgments.*

The writer desires to express his gratitude to Mr. W. P. L. Cameron, Assistant Entomologist, Sudan Government, for the study of the life-history from egg to final instar; and to Mr. C. J. Golledge, Librarian of the Imperial Bureau of Entomology, for compiling the appended list of references to the occurrence of *Agonoscelis* as a pest.



Adults of *Agonoscelis versicolor*, F., clustered during the resting period.

# THE STATUS OF ECONOMIC ENTOMOLOGY IN PERU.

By George N. Wolcott,

*formerly Entomologist, Estacion Experimental Agricola, Lima, Peru.*

The map of South America shows Peru as a rather long, narrow country, broadening at the north, and presumably tropical in climate judging by its position just south of the Equator, but with high mountains close to the coast. But it does not show the cold ocean current coming from the south—the Humboldt Current—or ar least we are not accustomed to noticing such presumably minor features, even though in the case of Peru, this is equal in importance with the mountains in determining the climate of the country and every factor that the climate may affect.

The cold current brings with it enormous numbers of fish, and although the Peruvians are not noted as fishermen, and indeed hardly supply even the requirements of the coastal settlements for fish, yet these schools of fish so close to the land affect it in a unique way. They furnish food for such enormous numbers of large birds that one can but be amazed at how numerous the fish must be to support so many, to say nothing of the seals and predacious fish that are less readily observed. These marine birds must have places to rest and rear their young, and such rocky islets as occur near the coast, and indeed all the more inaccessible promontories, furnish such rookeries. The guano which collects there is a cheap and abundant source of fertilizer, used not only in Peru, but exported in large quantities. The fact that the guano does collect in such amounts is an indication that rainfall is scanty or non-existent, otherwise it would be washed away.

The rainlessness of the coast of Peru gives it a most barren and forbiding aspect. The irrigated valleys are but a small fraction of the coastal area, and often are hidden from the ocean by hills, or all available water is used in the upper part of the valley where the stream supplying it emerges from between the foothills of the Andes. One feels cold enough so that the whitish patches on the promontories suggest snow, but on disembarking one finds that the land is really quite warm and the whitish patches are guano. Dust and rocks predominate, especially dust.

It is not entirely accurate to say that it never rains on the Peruvian coast. Even in ordinary years, there are light sprinkles of rain now and then during the summer evenings, and during the winter a blanket of fog extends all along the coast, being continually present both night and day for weeks, and sometimes for months at a time, without once allowing the sun to break through. The summer sprinkles of rain evaporate by morning, but when the fog bank descends, drops of moisture are precipitated on everything, and with no drying sun or wind to moderate the humidity, sufficient water accumulates between the rocks on the mountain slopes to support temporarily quite an abundant vegetation. Saxifrage and shamrock, bright-flowered solanums and yellow or orange lilies or amaryllis, flower in profusion for a few weeks and then disappear completely until another spring. Moss and lichens cover many of the rocks at all seasons, and small dust-coloured, pineapple-like plants (*Tillandsia* spp.) are so abundant on some sandy hills as to occur in wavy billows, and clever advertisers plant them out on exposed barren slopes to spell the name of their products.

Winter on the Peruvian coast seems to constitute the greater part of the year, and it is so cold that one must wear woollen clothes continually, despite the actual position of Peru, deceptively located, according to latitude, in the tropics. As the use of artificial heat is practically unknown, the houses and offices are more frigid and uncomfortable than when one is active out-of-doors. Yet semitropical crops such as cotton, sugar-cane and oranges are produced, even though for the greater part of the year they make practically no growth. Their cultivation is possible only because it

never gets cold enough to freeze, and despite the fact that summer is not especially long, nor the summer temperatures especially high during most years.

Despite their apparent outward similarity, the numerous coastal valleys display considerable individuality in climate, crops and population. In one of the most southern, Tambo, and to judge from its position alone, the coldest, sugar-cane is grown, although two years are required for producing stalks of sufficient size to be crushed. Oranges are grown on a rather extensive scale at Camaná, and grapes in valleys to the north, Ica and Pisco, wine production being a flourishing industry. In all of these valleys cotton is grown, and it constitutes the important crop of all of the valleys of southern and central Peru. Farther north, the large valley of Chicama is devoted almost entirely to sugar-cane, Central " Casa Grande " being the largest mill in Peru, and Central " Cartavio " second in size, while five smaller mills crush the cane produced in the valley of Chiclayo. The most northern valleys, Piura and Chira, have a climate which is truly tropical, possibly because they are north of the major promontory which deflects the Humboldt current away from the coast, but unfortunately this is not effectively utilised in growing cane. The cotton industry has been established there for many years, and although much of the crop is produced during the coldest part of the year, some planters insist on a summer crop, thus furnishing ideal conditions for insect pests. During recent years, the increasing number and abundance of insects attacking cotton in Piura has made cotton cultivation a risky or unprofitable business, and it is due to the importance of insects in this valley that the first Economic Entomologist was brought to Peru.

Many of these valleys have strong organisations of the larger landowners, but quite independent of each other or the central government, and the one in Piura engaged Dr. C. H. T. Townsend to come to Peru in 1909 to make recommendations concerning the " piojo blanco," or common white scale, *Hemichionaspis minor*, Maskell, which was considered to be the most serious pest affecting cotton. It can hardly be claimed that Dr. Townsend was especially successful in the avowed object of his coming to Peru, for if the white scale is doing less damage at the present time in Piura than before his arrival, this may in large part be due to many changes in cotton cultivation that have had a greater effect on it than any of his recommendations or the parasites which he was instrumental in introducing. Indeed, the white scale is continually extending its range in Peru, and at the present time is found in practically all the larger valleys producing cotton, with the exception of Cañete. The greater permanent value of his presence is that he pointed out some of the other less obvious pests of cotton and explained the insidious way in which they injured the crop.

The *Anthonomus vestitus*, Boheman, of Peruvian cotton is a much smaller insect than the form occurring in Mexico and the southern United States, and although the latter insect is a less injurious pest of bolls than of squares, the attack of the Peruvian species is confined exclusively to the squares. The falling of the squares due to this weevil was well known to the growers and had received a name, but none of them knew the cause until Dr. Townsend indicated the culprit.

For many years the use of arsenicals for killing the leaf-worms, *Anomis texana*, Riley, and *Alabama argillacea*, Hübner, has been a common practice in Peru, but their application was only by means of hand-operated spray pumps, even on the largest plantations. The cotton-growers association of the Cañete valley brought Dr. W. E. Hinds, Entomologist of the Louisiana Experiment Station, to Peru in 1925. Dr. Hinds was here for but a few months, yet his influence has been most profound. He suggested dusting the poison on the cotton plants, showed how home-made dusters could be constructed (relics of which are seen everywhere in Peru, piled up with the discarded spray pumps), indicated the desirability of using the improved hand and mule-back dusters that had been developed for use in the southern United States, and was also largely instrumental in having aeroplane application of calcium arsenate so widely adopted.

Mr. C. E. Woolman of the Huff-Daland Dusters, Inc., came to Peru in 1926, to make the preliminary arrangements, followed later by J. B. Pope, as Entomologist, H. R. Harris, in charge of operations, D. E. Tobin, H. E. Elliott and M. L. Alexander, as pilots, two mechanics and five aeroplanes, one of which was a passenger plane. During the first season, 1926–27, approximately 40,000 acres were dusted, a record which was practically doubled the next season with no larger personnel and only one additional aeroplane. As the figures indicate, aeroplane dusting in Peru is no "picayune" affair, but is already a standardised commercial practice, giving practically perfect results in the control of the leaf caterpillars. Indeed it is so effective, that in many cases where four or five applications by hand had been needed in the past, one or two by aeroplane were found ample, and preliminary estimates of the dusting to be done have been halved. Preliminary experiments indicate that arsenicals are also reasonably effective in the control of the Peruvian square weevil, and aeroplane dusting for this pest is being pushed everywhere, especially in Piura, although extensive field experiments to prove its value have yet to be made.

One of the most interesting recent uses of aeroplanes for insecticide application is connected with the cotton-stainer, *Dysdercus ruficollis*, Linn., a pest that differs in various characteristics from allied species attacking cotton in other countries. The Peruvian species is larger but less noticeable than its brilliantly coloured West Indian cousins, being dull yellow and dark brown and also less gregarious, but being more active and possessing strong powers of flight, it may at any time invade previously uninfested cotton-fields in enormous numbers. It is comparatively simple to control *Dysdercus andreae*, Linn., of the West Indies by collecting the first individuals to appear and destroying them, for being gregarious and disinclined to move so long as food is available, they do not tend to migrate from field to field. Hand-collection is also widely practised in Peru, but when swarms of adults fly in from other fields, some quicker and more immediately effective remedy must be used. On the foothills of the western slope of the Andes in northern Peru occur extensive forests of silk-cotton and other trees, which are acceptable alternate hosts to the stainers, and whether any great numbers of stainers do come from these distant sources rather than from fields near by, they certainly furnish a permanent reservoir where the stainers may breed without interference, and form a constant menace to the cotton fields. Merck, of Germany, is selling in Peru what is locally called "polvos violeta" or violet powder, although the manufacturer's name is "Si 26," which is claimed to be a perfect remedy for the stainer. The claims made for it seemed incredible; yet when dusted by aeroplane at the rate of ten pounds an acre in a cotton field heavily infested with stainers, 95 per cent. of the adults were dead within a few hours. The males are more susceptible to its baneful influence, and immediately after its application one sees active females still attached to dead males, but soon most live adults have disappeared, and only nymphs that have been protected from the poison by hiding in partly opened bolls are to be noted. The value of "polvos violeta" is largely in the control of the suddenly appearing swarm of adults, against which previously the cotton-grower has had no adequate protection.

The Aphid, *Aphis gossypii*, Glover, well known as a pest of cotton elsewhere, is often abundant during the cold, damp, cloudy weather frequently experienced at the beginning of the season in Peru. Ants are so scarce along the coast, both in species and in number of individuals, that they can remove but a small fraction of the honeydew secreted by the Aphids; consequently the leaves are soon covered with a black sticky film, locally termed "melaza." The Aphids in Peru have all the kinds of parasites and predators that keep them in check elsewhere, and with the advent of sunny weather, usually coinciding with the increase in numbers of the parasites, the plague of Aphids soon disappears, whether the growers have attempted to control it by spraying, or not.

The most characteristic pest of cotton in Peru is a weevil that burrows in the roots, *Gasterocercodes gossypii*, Pierce, and it is so abundant in the northern valleys that cotton can rarely be ratooned. Replanting each year prevents serious damage, but adds considerably to the cost of production as compared with the colder valleys to the south, where cotton is ratooned for many years.

There are many minor pests of cotton, some of which in certain fields or haciendas, or even in entire valleys, may cause major injuries. These have been more or less extensively discussed in a report issued in 1928 by Dr. Townsend, but many of them have been so little studied, and in many cases are not even identified, that the field of research on cotton insects of Peru may be considered as having been barely touched. New pests are being continually found, while much yet remains to be discovered concerning even those best known.

Sugar-cane has been cultivated in Peru for hundreds of years, and presumably the borer, *Diatraea saccharalis*, Fabr., has been its most important pest since earliest times. Yet surprisingly enough, in the valley of Tambo, the most southerly in which cane is grown, and one of the most isolated, it does not occur. In contrast with its absence in Tambo, the damage it causes in the upper part of some of the northern valleys is more severe than anywhere else in the world. In other countries, entomologists are accustomed to report the number of stalks injured, but in northern Peru no stalks are free from injury and ordinarily many caterpillars occur in each one. Sometimes fields of cane a year old are killed by the multitude of borers that infest the high cane. Despite the presence of parasites in abundance, the case seems hopeless at first, but as one begins to analyse conditions, it is found that there are numerous possibilities of reducing the damage due to *Diatraea*. At all mills, the trash of the cane is invariably burned before cutting, and changing this practise to cutting without burning either before or after harvesting may be expected to have a beneficial effect on the egg parasite, *Trichogramma minutum*, Riley, and a corresponding reduction in the number of borers. Already one small mill has progressed to delaying burning until after the cane is cut, and one large mill is about to start non-burning experiments, both merely preliminary indications of a change that may eventually greatly alter the borer situation.

The practice in Peru of planting enormous unbroken areas of cane at one time is not general elsewhere, but if it is possible to free such larger areas of the borer at planting time, the influx of moths on a large scale from outside will be slow, and the field largely escape infestation. Seed selection, or killing the borers in the cane by submergence in water for three days, are methods of obtaining clean, borer-free seed that have been developed elsewhere, but may be used to advantage in Peru. As elsewhere, however, it is more difficult to convince the field men of the importance of the prompt destruction of the discarded seed than of the benefits of seed selection itself. When cane is planted in Peru at the end of the warm weather or at the beginning of winter, the young shoots coming up are entirely free from borer, and even though they develop slowly, present an interesting contrast with fields planted at the opposite time of year, which may be so heavily attacked that not more than half of the shoots develop into stalks. Apparently there is a delicate adjustment of temperature here, so that it is too cold for the borer caterpillars in the seed-cane in the ground to continue their development, yet warm enough for the cane eyes to sprout and send out shoots, even though slowly. Before warm weather comes, they are so high that the cane has been cultivated once or twice and the seed buried so deeply that the moths cannot emerge through such a depth of earth. The effect of cold weather planting in eliminating the borer is more than temporary and is plainly evident for a year and a half, such cane not beginning to be heavily infested until the final months before it is crushed.

It has long been known that the borer is much less abundant where the annual rainfall is heavy, but it was hardly to be expected that in rainless Peru a parallel situation might be observed. Yet close to the coast, fields over which the fog hangs

for eight or nine months of the year are so free from borer as to indicate that water precipitated from low-lying fogs may be fully as effective in drowning borer caterpillars as that from rain. Nor is it so readily dissipated afterwards as that from sudden showers followed by intense tropical sunshine, for even when the fog lifts, it still shuts out the sun and wind which might dry the cane. Naturally, such cane, deprived of sunshine, is low in sucrose, but being comparatively free from borer, is admirably adapted, after selection, for planting in the upper parts of the valleys, where fogs are less common and borer more numerous.

There are surprisingly few other pests of importance attacking cane in Peru. What is presumably *Elasmopalpus lignosellus*, Zeller, sometimes causes considerable damage in young ratoon shoots, and the leaf-folder, *Marasmius trapezalis*, Guenée, when it occurs on very young cane, may damage more than the appearance of the leaves. But ants are so scarce that mealybugs are rare, and to find the scale-insects, *Aclerda sacchari*, Teague (?) and a species of *Targionia* which Dr. Morrison does not place, requires careful search. Damage by white grubs is exceptional, and their occasional abundance is noticeable because it is so unusual. The male adults of a rhinoceros beetle, *Golofa aegeon*, Linn., sometimes chew into young shoots and shred the leaves, but actual damage is slight. There is one endemic pest of cane, *Eumycterus* (?) *saccharidis*, Barber, which in years past has done considerable damage in some valleys, the small weevils making tunnels, red with rot, just under the rind of the cane-stalks, but at present its attack seems confined to stunted or discarded cane of little value.

The production of fruit, except grapes, is a very minor industry on the coast, but in years past, oranges were extensively grown. The accidental introduction of two scale-insects, *Lepidosaphes beckii*, Newman, and *Pseudaonidia* (*Selenaspidus*) *articulatus*, Morgan, and their wide dispersion, killed many of the older trees, and even at the present time no concerted attempt is made in the control of these pests.

Deciduous fruits are produced in small amounts, but their greatest enemy is the fruit-fly, *Anastrepha fraterculus*, Wiedemann. The habits of this fly have been studied by Sr. Gaudrón, of the local College of Agriculture, and Dr. Townsend even re-described it as new; but even though it may be morphologically similar to the one found in the West Indies, it is not so limited in its host adaptiveness, and its maggots are found in a great variety of fruits, especially peaches, pears and chirimoyas. Apples are attacked more rarely, also avocados, and many wild or local fruits, such as the wild progenitors of our cultivated tomatos. To ensure uninfested peaches, the fruit must be bagged when it is half-grown, and orchards with the trees covered with paper sacks are a common sight around Lima during the summer.

From the irrigated valleys of the coast comes practically all of the cotton and sugar which is exported, but the high sierras are not unproductive barren wastes. Rainfall is abundant, and although low temperatures may somewhat limit the luxuriance of vegetative growth, some hardy grasses grow in sufficient abundance to support large numbers of sheep, and the native llamas and vicuñas are a source of even more valuable wool and fur. In the lower valleys of the sierras, extensive fields of wheat and potatoes may be seen. The wheat produced in Peru is insufficient in quantity to supply even the needs of the country, but potatoes, which we miscall Irish, are indigenous in Peru, and rival the rainbow in the variety of the colouring of the tubers, besides being cheap and abundant. The ears of maize that one sees in the markets of the sierra towns display equally vivid colouring and primitive wild shapes, with exuberantly large kernels. Some of the beetles found in potato tubers exported from this region to the States some years ago were described by W. Dwight Pierce, but no one has studied the insect pests of these crops, and farmers are continually sending hitherto unknown insects to the recently established Experiment Station at Lima. In contrast with conditions along the coast, these independent peasant farmers recognise their insect pests and have both local Spanish and also Quechwa (Indian)

names for them, even though they are entirely innocent of thinking that anything could be done to kill them or prevent their injury to their crops.

The coast and the sierra we may think as distinctive of Peru and characteristic of the country, but beyond the high mountains, in the Amazon basin, is an area of tropical rain forest under Peruvian sovereignty equal in area to all the rest of the country. It is little developed and little known, its commercial exploitation being retarded by lack of transportation, rough topography and lack of interest in this section of the country by the Peruvians who live elsewhere. In extenuation of this attitude, it might be mentioned that without spending nearly a month of muleback travelling by little-used trails through an unbroken jungle, the most practical way of getting from the principal city of this region, Iquitos, to Lima, up to a year ago, was *via* New York. Even at the present time, when there is a weekly aeroplane-hydroplane service to Iquitos, the one way fare is $800. Some of the products of this jungle are better known than the region from which they come : coca, Peruvian chinchona or quinine, balsam of Peru, besides other drugs, and rubber, in the years when the Amazon basin supplied the world.

Of the agricultural products that are really grown and cultivated in this tropical rain forest, as contrasted with those that are merely collected, coffee is logically first, for the climate and contour of the country are well adapted to its cultivation, insect pests are scarce, and the product is of such concentrated value as to repay the high cost of getting it to market. For the same reason, sugar-cane is turned into alcohol. While the caterpillar borer, *Diatraea*, which is such a serious pest on the coast, is of relatively slight importance here, where heavy rainfall keeps its numbers reduced to a minimum, two weevil borers, *Metamasius* spp., and termites often attack rat-injured cane. Cotton is also cultivated on the more level lands adjacent to navigable rivers, which render its transportation to market not too costly, and the pink boll-worm, *Pectinophora gossypiella*, Saunders, which is known to occur in most parts of Brazil, has apparently not yet penetrated to this region.

Of the horticultural crops, pineapples, bananas and papayas do extremely well, being devoid of insect pests, and are extensively grown where they can be transported to a market. The scale-insects found on the citrus trees of the coast are also found here, but not in sufficient abundance to cause appreciable injury, possibly because of their natural control by entomogenous fungi. The serious pest of citrus and avocado trees is the " coqui," the parasol or fungus-growing ant, *Atta sexdens*, Linn., var., which often denudes a tree of its leaves overnight. Growers able to afford the force-pumps and calcium cyanide, which will destroy the queen and her progeny in their subterranean burrows, have little to fear from the ant, if they will take the requisite precautions of destroying all the colonies within a reasonable radius of their plantations. Most of the growers are poor, however, and fatalistic in their attitude towards the " coqui." Some of them patiently renew every three days the bands of banana leaves around each tree, or as often as the leaves wither, for fresh banana leaves will invariably stop the ants. Others rely on larger quantities of dry leaves, or tin barriers. One sometimes sees five gallon cans full of earth tied around large branches of avocado or citrus trees. As soon as roots start growing, the branch is cut off and planted in the ground, the idea being that such trees will be less liable to attack than smaller ones, or that the tin can will protect it. It seems very childish to us, but is widely practised, and apparently everybody believes in its value and efficacy.

The number and abundance of insects in this region can scarcely be imagined, except by those who have been there. Swarms of many different kinds of butterflies of all sizes and colours abound, and flocks of them gather in every glade where the path crosses a stream. The collection of butterflies for export is a minor industry, and many of the native and Indian children that one sees are provided with nets and are

making collections for some foreigner who is managing the export part of the business. Man may artificially produce anilin dyes to take the place of the cochineal, which was once grown on a large scale in many parts of Peru, traces of the industry in the shape of large spineless cactus plants white with the innumerable cochineal insects (mealybugs) covering them being still visible, but artificial butterflies can never displace the insects themselves.

# INJURIOUS HISPINAE FROM THE SOLOMON ISLANDS.

By S. Maulik.

The material on which the following notes are based was submitted to me for study by the Imperial Bureau of Entomology. It is necessary to describe two new genera and three new species. The material contains two larvae, on which remarks have also been made.

The drawings were made by Mr. D. E. Kimmins.

## Genus **Pharangispa**, nov.

Body small, nearly parallel-sided, with the apex rounded. *Head* as broad as the prothorax; eyes strongly convex; antennae eight-segmented, the third segment the longest, last segment bluntly pointed, the seventh and eighth segments with round sensory pits. *Prothorax* longer than broad; sides without margin, rounded; upper surface with coarse pits, and depressions, central area convex. *Scutellum* triangular, with the apex broadly rounded. *Elytra* broader at base than the prothorax; punctate-striate; without a scutellar row of punctures; the punctures are so large and so close to each other, that the interstices between the rows are not well defined. *Underside*: legs not short; two segments preceding the claw segment of tarsi bilobed; claw-segment shorter than the previous bilobed segment; claws simple.

Genotype, *Pharangispa purpureipennis*, Maulik, sp. n.

In not possessing a scutellar row of punctures on the elytra *Pharangispa* is related to the genera included in the groups Exothispini, Coelaenomenoderini, Promecothecini, Gonophorini; but it cannot be suitably placed in any of these groups because of the reduced number of the segments of the antennae. Among the Old World Hispinae the phenomenon of reduction in the number of these segments occurs in only two known genera, namely, *Rhabdotohispa*, Maulik (Trans. Linn. Soc., xvi, 1913, p. 239), and *Platypria*, Guérin (Rev. Zool., 1840, p. 139). In the latter the species are spiny and do not, therefore, concern us here. In the form of the body both *Rhabdotohispa scotti*, Maulik, and *Pharangispa purpureipennis*, sp. nov., have a certain resemblance to some species of *Coelaenomenodera*, but both differ in the number of the antennal segments (six in *Rhabdotohispa* and eight in *Pharangispa*), *Coelaenomenodera* having the usual eleven segments of Chrysomelid beetles.

## **Pharangispa purpureipennis**, sp. nov. (fig. 1).

Colour generally yellow-brown with the underside somewhat lighter; the elytra, with the exception of a small humeral area, the narrow margin on each side, and a small apical area, deep purple; third to eighth segments of antennae pitch-brown, more blackish towards the apex; sometimes the pitch-brown colour becomes very light. The upper side is more shining than the underside.

*Head* with the vertex impunctate, but sometimes with a pit in the middle interocular space with a raised longitudinal median area, which is continued between the antennae. Round the roots of the antennae a considerable area is excavated. The first segment of antennae shorter than second; third about equal to first and second together; fourth to seventh about equal to each other, each being much shorter than either the third or eighth, the latter ovate; the six basal segments are more shining, sparsely hairy and covered with elongate punctures; seventh and eighth densely covered with hairs, the latter having nine round sensory pits arranged in longitudinal rows of three; on the seventh only one pit situated near the apex

externally in a line with a row of three on the eighth. *Prothorax* oblong, with the sides convex at the middle, somewhat constricted at base ; basal margin bisinuate ; anterior lateral angles acute, each with a fine seta, which can be seen only under a high power. Upper surface with three depressions at base, one median opposite the scutellum and two lateral which vary in depth ; covered with large, coarse punctures, but with smooth areas which are without any pits or punctures. *Scutellum*

Fig. 1. *Pharangispa purpureipennis*, sp. n.

impunctate, the apex varying slightly in width, sometimes quite broad and sometimes appreciably narrower. *Elytra* with ten parallel longitudinal series of punctures including an extreme marginal row, the punctures being large closely placed and deep; the lateral margins narrowly explanate. *Underside* smooth, impunctate, without hairs. The first two abdominal sternites not fused.

*Length*, 5·5 mm. ; length of antenna, 2·25 mm.

Solomon Islands : Guadalcanar, Ilu-Tenaru, viii–1928 (*R. W. Paine* and *J. D. Tothill*) ; Tunibuli, Ysabel, 11.x.1928 (*R. W. Paine*) ; Malaita, Su'u, 8.ix.1928 (*R. W. Paine*).

There are 22 examples, ten of which are not in good condition. All were found on " ginger in bush."

*Type* in the British Museum.

*Larva* (fig. 2) : Length (alcoholic specimens) 3·0–4·5 mm. The body gradually narrows from the prothorax (which is the broadest part) to the last abdominal segment. Each abdominal segment is rounded on either side and without any projection or spine, although there are a few hairs. The head is of the leaf-mining type, being large, strongly chitinised and bilobed, and mostly embedded in the prothorax. The mouth-parts consist of a thickly fringed labrum, two sharply triangular mandibles

and also a densely fringed labium. The antennae (fig. 2, *a*) have a broad base bearing three segments ; internal to the third is a lobe ; the third segment bears seven setae of various sizes. The prothorax is extensively chitinised, more strongly so at the

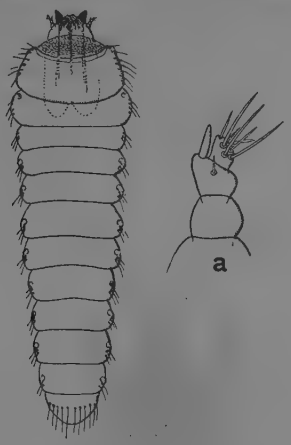



Fig. 2. *Pharangispa purpureipennis*, sp. n., larva ; *a*, right antenna.

anterior end on both the dorsal and ventral sides, where the surface is strongly shagreened. The description is taken from preparations made from two specimens, one presumably full-fed and the other evidently young.

Genus **Aulostyrax,** nov.

Body oblong, parallel-sided, extreme apex of elytra narrowed. *Head* narrow, with the interocular space raised, channelled and bluntly produced between the antennae. The upper edge of the cavity in which the mouth-parts are situated is not close to the roots of antennae, the clypeus being produced. The antennae are eleven-segmented, with the first segment very large ; four or five apical segments with sensory areas on the underside. *Prothorax* almost quadrate, with four sharp corners. *Elytra* much broader at base than the prothorax, without ribs, punctate-striate, the rows of punctures close to each other ; the interstices somewhat raised. *Underside* : intercoxal process of the prosternum much broadened behind, its surface with a few pits. Legs short, completely covered with coarse pits ; femora thickened ; front tibiae expanded at the apex ; tarsi broad, all segments bilobed ; claws strong.

GENOTYPE, *Aulostyrax nuciferae*, Maulik, sp. n.

At first sight there is a certain resemblance to the genus *Oxycephala*, Guér. The form of the body is elongate in both genera, and the structure of the head is similar. But *Aulostyrax* differs from *Oxycephala* in not having the upper surface shining, and in having no ribs on the elytra. There are other differences, but these two are quite sufficient to distinguish the new genus.

**Aulostyrax nuciferae,** sp. nov. (fig. 3).

Body oblong, parallel-sided, flattish. Head, antennae, thorax, underside and legs black ; about the basal third of elytra bright orange-brown, the remaining two-thirds black, with a greenish-blue tint on the discal area. Scutellum black. Pubescence on the underside of tarsi brown. Upper surface subnitid, underside more shining.

*Head* obliquely placed in the prothorax ; interocular space raised, coarsely punctate, with a median, longitudinal and deeply-impressed channel, which is continued on the dorsal side of the bluntly pointed interantennal process. Eyes large, ovate. Clypeus elongate, parallel-sided, with a channel along each side, with a discal excavation containing a median longitudinal ridge, and with closely placed pits bearing fine long yellowish hairs ; the lateral channels also bear punctures, but no hairs. Antennae with the first segment large, cylindrical, and much thickened, its surface coarsely punctate ; second very small, coarsely punctate ; third very slightly longer than fourth ; fourth, fifth, sixth, seventh about equal in length ; eighth, ninth, tenth shorter, about equal ; eleventh somewhat longer ; third to seventh

Fig. 3. *Aulostyrax nuciferae*, sp. n.

segments slender, cylindrical, subnitid and covered with fine punctures ; eighth to eleventh segments somewhat laterally flattened, more shining and with finer punctures ; the extreme apex flattened and with fine whitish pubescence which is continued along a narrow area on the underside of the tenth, ninth, eighth and a small part of the seventh segment. The function of this modified antennal surface is no doubt sensory. *Prothorax* quadrate, somewhat narrowed in front, sides parallel, basal margin lobed in the middle ; sharply produced at each of the four corners, the anterior ones bearing an oblique short sharply-raised ridge ; upper surface more or less flat, densely covered with coarse punctures, the interstices also very finely punctate ; underside coarsely punctate, except a lateral strip which is impunctate. *Scutellum* small, triangular, with the apex rounded, the exposed surface impunctate. *Elytra* much broader at base than the prothorax, parallel-sided ; lateral edges slightly but distinctly explanate. Each elytron with nine longitudinal series of punctures across the basal area (including a scutellum row) but ten across the middle, the row from the humerus dividing into two on the greenish-blue patch ; the interstices costate but more flattened on the discal area, and their surface rugose and finely punctate ; the narrow explanate edge also rugose. *Underside* generally smooth, without

hairs ; intercoxal process of the prosternum much expanded behind, rugose, with a few strong and more fine punctures ; legs short, completely covered with coarse pits ; the basal halves of the femora smooth shining and finely punctate ; femora thickened ; tibiae shorter than femora ; tarsi broad, with the three basal segments bilobed ; the claw segment not projecting beyond the previous segment ; claws strong, divaricate : abdominal sternites very finely and somewhat sparsely punctate.

*Length*, 12 mm. ; greatest width across elytra, 4·5 mm. ; length of prothorax 2·5 mm. ; length of antenna, 6 mm.

SOLOMON ISLANDS : Malaita, Auki, 11.ix.1928, " feeding in base of unopened leaflets of coconuts " (*J. D. Tothill*). Described from four examples.

*Type* in the British Museum.

Fig. 4. *Pharangispa purpureipennis*, sp. n., last two antennal segments, showing sensory areas.

Fig. 5. *Aulostyrax nuciferae*, sp. n., last antennal segment, showing sensory area.

*Sensory areas of Antennae.*—In regard to the sensory areas of *Rhabdotohispa scotti*, Maulik, I wrote as follows : " It has not been possible to examine satisfactorily the minute structure of the surface of the excavation, but a balsam preparation under a high power shows the presence of small groups of papilliform structures situated in pits which are surrounded by a dense mass of a special form of short setae." In the case of *Pharangispa purpureipennis*, Maulik (fig. 4), it would appear that the sensory

places are small membranous areas almost without any papilliform structures or hairs, although they may be surrounded by a ring composed of such structures, while the sensory area in *Aulostyrax nuciferae*, sp. n. (fig. 5), shows that the chitin has become thinned and is closely covered with hairs or setae.

**Promecotheca alpiniae,** sp. nov. (fig. 6).

Body oblong, nearly parallel-sided, being slightly convex behind the middle, apex somewhat narrowed. General colour shining brown, with a purplish-blue patch on the elytra, occupying approximately the median third and extending in front narrowly along the suture almost to the scutellum, but here much diluted and

Fig. 6. *Promecotheca alpiniae*, sp. n.

almost fading to dark brown; the hind margin of the purplish-blue patch is ill-defined, extending more towards the apex along the lateral margin than along the suture; with the colour sometimes much diluted. Abdominal sternites somewhat darker. All the segments of the antennae except the basal two black.

*Head* as broad as prothorax, with the vertical area smooth, impunctate; eyes strongly convex. Antennae extending beyond the humerus; first segment short, thickened; second also thickened but less so than the first, and constricted at the base; third to sixth slender, each being slightly longer than the following segment, sparsely covered with longish brown hairs and with punctures which are lengthened into streaks; from the seventh the segments are somewhat thicker, more hairy and with the surface rougher; seventh and eleventh about equal, the latter being bluntly pointed; eighth, ninth and tenth shorter and about equal to each other. *Prothorax* longer than broad, constricted at the apex, much more so at the base, so that each side at the middle is strongly convex. Each corner with a fine seta. Upper surface

smooth and (seen under a high power) with very minute scattered punctures. *Elytra* much broader at base than the prothorax, with ten longitudinal rows of punctures, and without a scutellar row. From the base to the end of the purplish-blue patch the surface is strongly transversely wrinkled, this rugosity interfering with the regularity of the longitudinal rows of punctures. The fringe of hairs at the apex fairly long. *Underside* less shining than the upper side ; impunctate, the abdominal sternites somewhat rugose laterally, and scattered with fine, fairly long hairs. Middle femora longer than the front ones, and the hind ones longer still ; all the segments of the tarsi bilobed ; claw segment short ; claws well developed.

*Length*, 7·5–9 mm.

Solomon Islands : Malaita, Su'u, 10.ix.1928, on *Alpinia* sp. (Zingiberaceae) (*R. W. Paine*). Described from three examples.

*Type* in the British Museum.

# THE FIRST STAGE LARVA OF LAC INSECTS.

By S. Mahdihassan.

Imms & Chatterjee[1] in their classical study of the lac insect say: "In the newly hatched larvae the sexes are indistinguishable by any external characters and it is not until after metamorphosis has set in that the separation into sexes becomes evident. We have examined a large number of the newly hatched larvae of *Tachardia lacca* and other Coccids and have been unable at this stage to find any external manifestation of the sexes." There is not a word separating the first from the second sentence of the above statement, yet Negi[2], in his recent contribution on the lac insect, who also quotes Imms' & Chatterjee's first sentence, erroneously credits the second part of their statement to me. Further, in my paper on lac insects[3] there is a photographic reproduction (Pl. ix, fig. 26) of two larvae of different sexes which are only four days

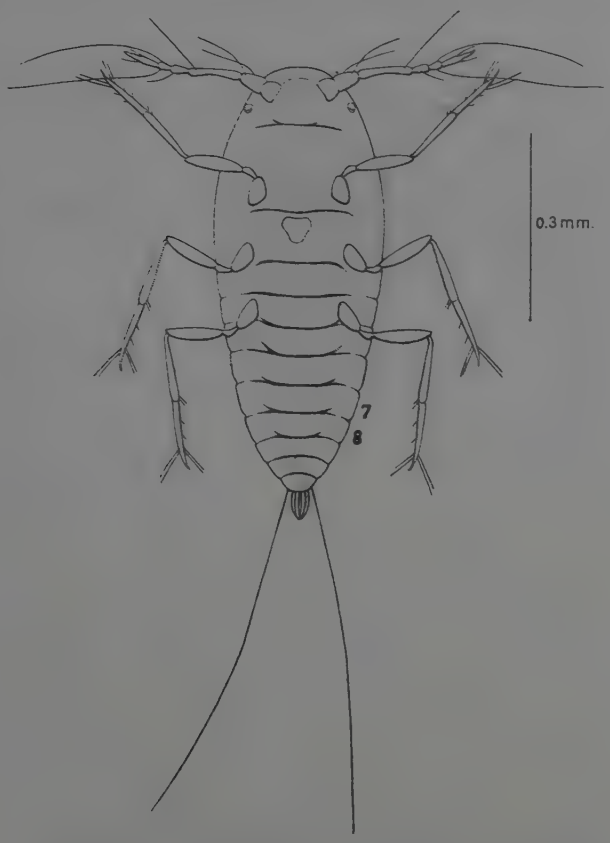



Fig. 1. Crawling larva of winged male lac insect, ventral view.

old. Again, figs. 17 and 18, on Plate vi, are male and female larvae, which have been only 24 hours on the tree and are for all purposes identical with crawling larvae.

Imms & Chatterjee give the dorsal view of a crawling larva, and with regard to this I commented (*loc. cit.*, p. 19) : " Fig. 7, Pl. ii, of (their) paper represents a male." Likewise I found a female crawling larva had also been unwittingly figured elsewhere, for I stated (p. 19) " Fig. 4, Pl. xix, of Green's paper[4] illustrating the larva of *T. fici* would appear to belong to a female." I therefore also identified the sex of crawling larvae as illustrated by previous workers.

I reproduce here ventral views of crawling larvae of both sexes. Fig. 1 represents the larva of the winged male of *Lakshadia* (*Laccifer*) *communis* derived from *Ficus mysorensis*, at Bangalore, 5th November 1925. The brood from which the specimen illustrated was derived was partly used to infect a host-plant, and the colony was observed till shortly after the first moult, when it was found that all belonged to the winged male. In the light of previous observations on the sex-ratio variability of this species, I could have no doubt as to the identity of the sex. Fig. 1 here, it may be

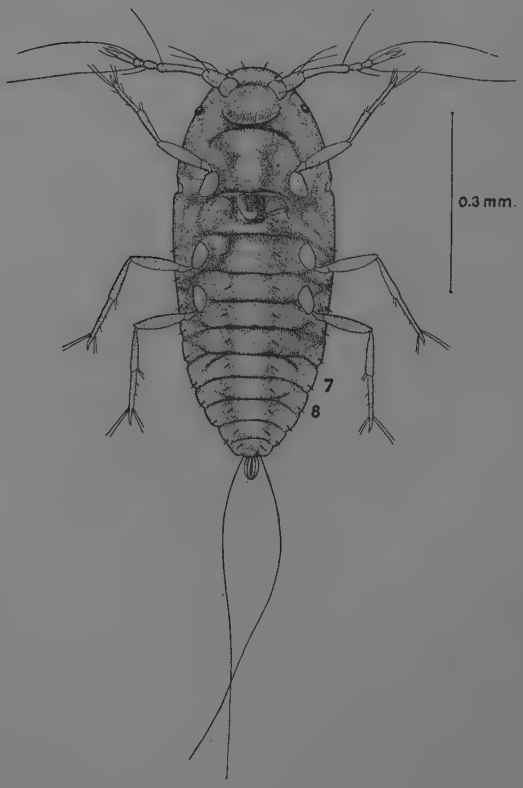



Fig. 2. Crawling larva of female lac insect, ventral view.

observed, is allied to Pl. ii, fig. 8, of Imms & Chatterjee in general shape and the tapering posterior part of the body. I confess, however, that in the crawling larval stage the winged and wingless males appear to me to be indistinguishable, and the

above illustration is reproduced in the hope that points of distinction may be discovered by others later on. I have already shown that after some growth the winged and wingless males can be differentiated before their first moult. Fig. 2 represents a female *Lakshadia* (*Laccifer*) *mysorensis* from *Shorea talura*, at Bangalore, 1st October 1925, and is comparable in outline and general shape with Green's illustration mentioned above. It will be noted that the abdomen does not taper posteriorly nearly so much as in the male larva.

Negi apparently does not appreciate the importance of early sex-ratio finding. Lac crops have been known to be very variable in quantity, and experts have previously attributed this sometimes to the ignorant cultivator, sometimes to the weather. This variability is to a certain extent directly due to sex-ratio variability, as I have already endeavoured to show.

*References.*

(1) Indian Forest Memoirs, Dehra Dun, iii, pt. 1, 1915, p. 17.
(2) Bull. Ent. Res., xix, 1929, p. 327.
(3) J. Indian Inst. Sci. Bangalore, ix, pt. 1, 1926.
(4) Indian Museum Notes, v, 1903, p. 97.

# METHODS OF INVESTIGATING THE FAUNA OF TREE-STUMPS.

By Ivar Trägårdh, D.Sc.

*Chief Entomologist, Swedish Forest Experiment Station.*

Ever since forest entomologists began to inquire into the interrelation between the action of the forester and the prevalence of noxious insects, the pine weevil (*Hylobius abietis*) has been quoted as a classical example of what unfortunate results large clean cuttings and planting on and in the vicinity of the cut-over areas may produce. This is due to the fact that the females oviposit under the bark of the stumps, where the larvae make their long tunnels far down into the roots of the trees and that large clean cuttings offer them greatly increased facilities of ovipositing in suitable places. At the same time the great number of young pine—or spruce-plants—offer the emerging weevils plenty of tender and nourishing food. The same thing happens if in the vicinity of a successful plantation an area is cut over; the only difference being that in this case the young plants are attacked in the spring following the cutting by weevils attracted by the smell of the stumps but not yet sexually mature until they have fed on the young plants, whereas in the former case the injury appears 2–3 years after the cutting, when the beetles of the next generation appear.

In Sweden the life-history of the pine weevil has not yet been thoroughly investigated, most of our knowledge being based on the extensive researches of German entomologists, but during recent years this problem has been studied, and it is my intention to describe briefly the methods used, and the results obtained by them, in the hope that they may further the investigation of root-inhabiting insects generally The study of these insects presents great difficulties owing to the fact that the larvae live under the bark underground, which makes direct observations almost impossible, especially if one is handicapped by shortage of labour, as is the case in Swedsn, where the whole staff of the Forest Entomological Department consists of only two scientists, who must of necessity devote their time to quite a number of other problems, including the investigation of the fauna of the soil, which necessitates extensive travelling throughout the season. This naturally prevents the use of cages round the stumps, in which the emergence of the beetles and their development could be observed by constant watching and examination, and the measuring of the temperature and moisture of the soil. Therefore other means of obtaining data regarding the development of the weevil must be resorted to, such as the repeated examination of stumps of pine and spruce left both in stands and in felled areas and the use of the so-called

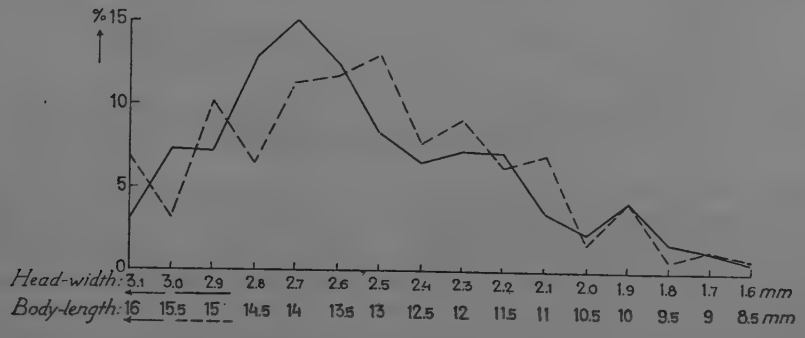



Fig. 1. Diagram illustrating the variation in head-width and body-length of 330 pine-weevil larvae collected on 5th November in trays prepared in the middle of May.

Grohmanns' trap (described by Munro in Forestry Commission Leaflet no. 1, p. 6) in order to obtain material of the brood of known age. Data obtained in this way have been supplemented by the results of extensive collections made by Forester Hj. Sylvén, who kindly put them at my disposal.

In order to ascertain the variation in size of the larvae at the end of one season, about 330 larvae, obtained on 5th October in traps prepared in the middle of May of the same year, were measured as to the width of the head-capsule and the length of the body. The curve in fig. 1 illustrates the result. The length of the larvae varied between 8·5 and 18 mm., and the width of the head-capsule between 1·6 and 3·1 mm.

The method of using the size of the head-capsule when studying the growth and the number of moults in insect larvae was first devised by Dyar (1890), who, as a result of the study of Lepidopterous larvae, formulated the law that the head-width follows a regular geometrical progression in successive instars, the average ratio of increase being constant. On the other hand, Simanton and Back & Cotton have found that in Coleopterous larvae the ratio of increase diminishes with advanced age from 1·44 during the 1st and 2nd ecdyses to 1·26 in the 3rd (*Hyperaspis*) or from 1·44 during the 1st ecdysis to 1·3 during the 2nd and 3rd (*Calandra*); and Kreyenberg has found that in *Dermestes lardarius* the number of moults increases with a lowering of the temperature. It is therefore not very probable that the curve in fig. 1 can be used for the purpose of ascertaining the number of instars in *Hylobius*. But it is nevertheless noteworthy that if we assume that the apices of the curve at 3, 2·7, 2·2 and 1·9 mm.

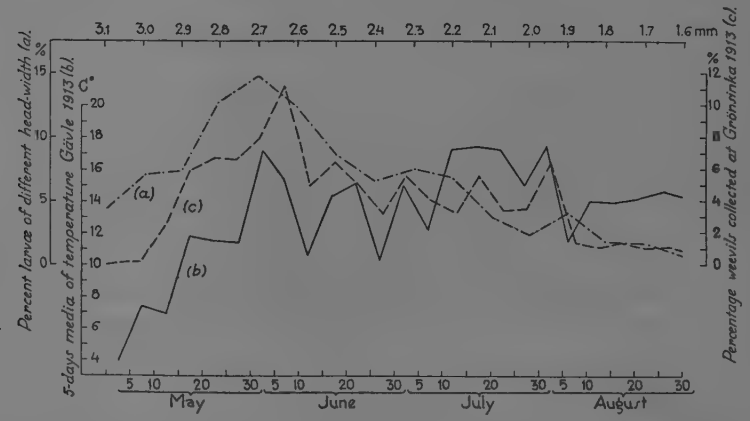

3.1 3.0 2.9 2.8 2.7 2.6 2.5 2.4 2.3 2.2 2.1 2.0 1.9 1.8 1.7 1.6 mm
Percent larvæ of different head-width (a).
5-days' media of temperature Gävle 1913 (b).
Percentage weevils collected at Grönsinka 1913 (c).
(a)
(c)
(b)
5 10 20 30 5 10 20 30 5 10 20 30 5 10 20 30
May
June
July
August

Fig. 2. Diagram illustrating: *a*, the variation in the head-width of pine-weevil larvae at the end of the season; *b*, 5-day means of temperature at Gävle in 1913; *c*, the number of weevils collected during May-August at Grönsinka, not far from Gävle.

represent the last four instars, their ratio of increase is exactly the same, viz., 1·1. If we assume the ratio of increase to be somewhat greater for the first ecdysis, e.g., 1·3, we arrive at the number of 6 instars in *Hylobius*: 1st, 1 mm.; 2nd, 1·46 mm.; 3rd, 1·9 mm.; 4th, 2·2 mm.; 5th, 2·7 mm.; 6th, 3 mm.; assuming that the head-width of the first instar is 1 mm. No reliance can be placed on this calculation, which has only been made in order to call the attention of entomologists to the desirability of obtaining exact data regarding the growth of the larvae. To return to the curve, it is evident that the variation in size of the larvae may be due not only to their representing different instars, but to the influence of temperature, humidity and

quality of food on the same instars. In the latter case one would, however, expect the curve to be symmetrical, since the traps where the material was collected offered different conditions. If, on the other hand, the shape of the curve illustrates the fact that most of the eggs were laid in the spring and early summer and had developed full-grown or nearly full-grown larvae, one would expect the curve to have the oblique shape it has. Fortunately the data given by Sylvén (1927) enables us to

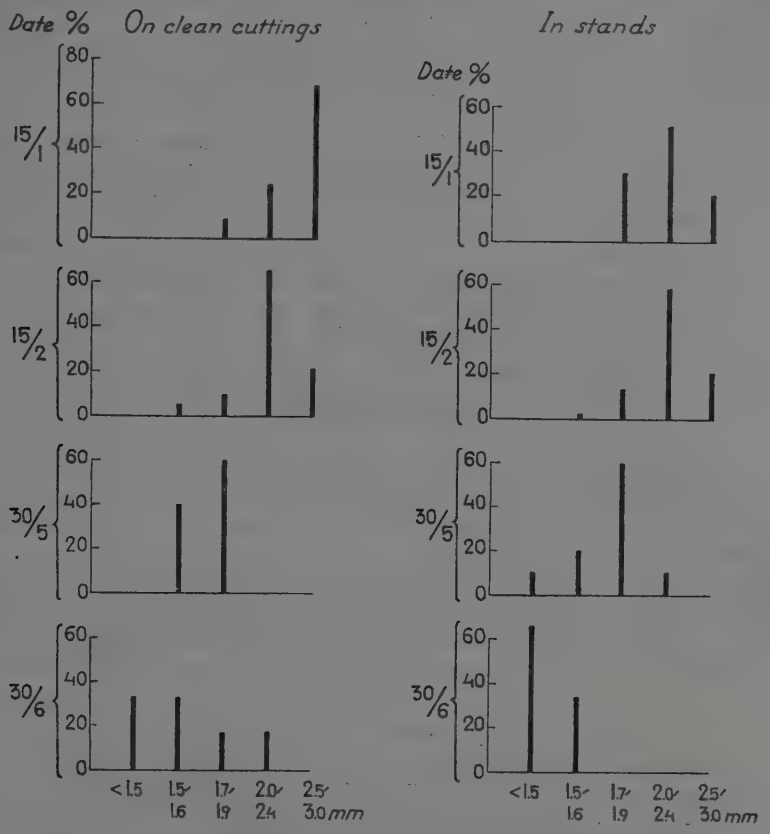



Fig. 3. Diagram illustrating the size of pine-weevil larvae (head-width) in stumps on clean cuttings and in stands, at different dates.

decide between these alternatives, because his collections of the full-grown weevils show that their greatest frequency occurs at the end of May and in June (fig. 2, curve *a*), the varying frequency being itself evidently due to the variation of temperature (fig. 2, curve *b*), which closely coincides with the results of the trapping. The chief period of oviposition of *Hylobius* is therefore the last half of May and the beginning of June.

In order to ascertain how far the position of the stumps (*i.e.*, on cuttings exposed to the sun or in stands) and the time of the year when the trees were cut influenced the degree of oviposition and the rate of development of the larvae, the stumps that

were cut throughout 1921 were investigated in May and September 1922 and in May 1923, the larvae being collected and their head-width measured. On the basis of these measurements the larvae were divided into 5 groups: less than 1·5, 1·5–1·6, 1·7–1·9, 2·0–2·4, and 2·5–3·0 mm., and the percentage of larvae belonging to these groups was calculated. Fig. 3 gives the results of such an investigation in May 1922 of pine stumps from January to June 1921 on a cutting and in a stand. We notice that in stumps from January and February 80–90 per cent. of the larvae in the following spring belong to the two groups with the greatest head-widths whereas in stumps from May or June 80–100 per cent. of the larvae had a head-width of less than 1·9 mm. and corresponded to the smallest size groups from Forssjö (fig. 1). This confirms the view expressed above that the development of the larvae is far more rapid in stumps on cuttings than in the stands.

The development of *Hylobius abietis* in the middle of Sweden has the following course in the traps (fig. 4). About 70 per cent. of the larvae are full-grown in the autumn and hibernate as larvae in their pupal chambers. From the last half of July to August next year, the larvae pupate, and some beetles emerge in the autumn,

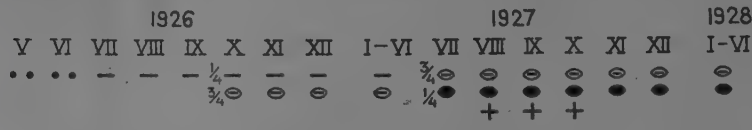



Fig. 4. Development of the pine-weevil in central Sweden according to observations in trays at Forssjö: • = egg; — = larva; ⊖ = larva resting in pupal chamber; ● = pupa; + = full-grown weevil.

many however hibernating a second time as pupae or larvae. On account of the low temperature in the autumn, it is very unlikely that the newly emerged beetles have time to finish in the same year the feeding that is necessary previous to mating and oviposition, an assumption which is borne out by the results of the trapping already mentioned (fig. 2, curve *c*).

In stumps from trees cut at different times we notice the following features. Those from January-March are decidedly preferred and quite full of larvae, while those from April-July only harbour single larvae, which were full-grown in May two years later. The stumps from August, on the other hand, were quite full of larvae, which evidently developed from eggs laid in the spring after the felling, since the

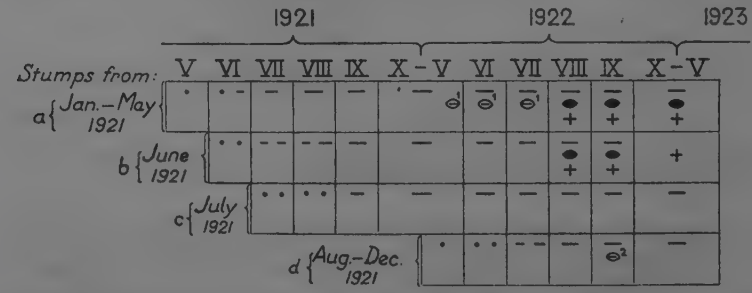



Fig. 5. Development of the pine-weevil in trunks, at different dates, at Gammelkrappa.

result of the collecting does not warrant the assumption that in August a sudden great increase in oviposition occurs. Moreover, these stumps agree in this respect completely with those from September and later months, which could not possibly have been oviposited in until the following spring.

There is, as a consequence, normally a period of about four months, April–July, when the trees may be cut and the stumps left in the ground without any danger of the pine-weevils increasing considerably. Unfortunately it is not possible to make use of this fact by altering the usual time of cutting the trees, which is in the winter. But I might suggest that when small felled areas in which reproduction has occurred are enlarged, it would be advantageous to choose a time as unsuitable as possible for the increase of the beetle and for injury to the young plants. It must, in this connection, be pointed out that when the stumps are left in the ground they play a twofold part in the biology of the weevil. In the first place, the beetles, although not sexually mature, are attracted to the stumps by their smell and feed on the young plants in their vicinity before ovipositing; secondly, the insects use the stumps as breeding places. Hence the injury to the plants is lessened appreciably if the felling is enlarged during the last half of the summer, when the beetles are scarce, and is to a great extent deferred till the following spring. There is also the possibility of diminishing the power of attraction of the stumps by decorticating them in the autumn, although nothing definite is known about this.

Hitherto attention has only been paid to the differences in the rate of development and degree of attack of the pine-weevil in stumps from trees cut at different times of the year. But from the first it became evident that the beetles greatly preferred the stumps on clean cuttings to those in the wood. This difference was especially remarkable in the case of spruce, a feature which undoubtedly is explained by spruce forests being as a rule denser than pine forests, which makes the differences between the temperature of the air and the temperature and humidity of the soil in the felled areas and in the forests greater in the case of spruce than in that of pine.

The following table illustrates this and shows that the light wood agrees in this respect with the clean cuttings.

TABLE I. *The Frequency of Weevil Larvae in May 1922 in Spruce Stumps.*

| Time of cutting. | In clearings. | In light wood. | In dense wood. |
|---|---|---|---|
| 15.i.1921 | Normal | — | No larvae. |
| 15.ii.1921 | Scarce | — | ,, ,, |
| 15.iii.1921 | ,, | — | One larva. |
| 15.iv.1921 | Normal | Normal | — |
| 15.v.1921 | ,, | ,, | — |

Some years later this observation was verified by new experiments, when the number of larvae was counted. In stumps of pine from 15th April on clean cuttings the average number of larvae was 44, but in the wood only 16. In stumps of spruce the corresponding figures were 19·5 and 0. This feature seems to be of considerable interest. Hitherto the occurrence in great numbers of the pine-weevil on clean cuttings and the great injury caused to the young plants on or in the vicinity of the cuttings has been attributed mainly to two causes: on the one hand, the greatly increased facilities of breeding in the numerous stumps; on the other hand, ample supply of appetising food for the adult beetles in the young plants in the vicinity of the stumps. From the foregoing experiments it is evident that a third factor plays a very important part, viz., *that the beetles are especially attracted to the stumps on the cuttings.*

*This feature constitutes another powerful reason for abandoning the practice of large clean fellings and extensive planting in favour of promoting reafforestation by means of thinning and opening small areas for replanting.*

*References.*

BACK & COTTON. The Granary Weevil.—U.S. Dept. Agr., Bull. no. 1393, 1926.

DYAR. The Number of Moults in Lepidopterous Larvae.—Psyche, v, 1891.

KREYENBERG. Experimentell-biologische Untersuchungen über *Dermestes lardarius*, L. und *D. vulpinus*.—Zs. f. ang. Entom., 1928.

SIMANTON. *Hyperaspis binotata*, a Predatory Enemy of the Terrapin Scale.—J. Agric. Res., vi, no. 5, 1916.

SYLVÉN. Snytbaggarna. Studier och fångstförsök.—Skogsvårdsfören. Tidskr. 1927.

The following collections were received by the Imperial Bureau of Entomology, between 1st April and 30th June, 1929, and the thanks of the Managing Committee are tendered to the contributors for their kind assistance :—

Australian Institute of Tropical Medicine, Townsville :—2 Coleoptera and samples of peas damaged by them ; from North Queensland.

Mr. A. Balachovsky :—54 Orthoptera ; from Algeria.

Mr. E. Ballard, Chief Plant Pathologist :—130 Parasitic Hymenoptera and 150 cocoons ; from Egypt.

Prof. H. A. Ballou :—54 Coleoptera ; from Trinidad.

Mr. G. E. Bodkin, Government Entomologist :—9 Diptera, 112 Coleoptera, 4 Chalcididae, 27 other Hymenoptera, 39 Lepidoptera, 12 Rhynchota, 6 Planipennia, 8 Odonata, and 4 Crustacea ; from Palestine.

Dr. G. Bondar :—116 Coleoptera, 5 Lepidoptera, and 1 species of Coccidae ; from Brazil.

Dr. G. E. Brooke :—2 Culicidae and 20 Coleoptera ; from Sarawak.

Dr. P. A. Buxton, London School of Tropical Medicine :—10 Coleoptera ; from Sierra Leone.

Mr. R. N. Chrystal :—5 Parasitic Hymenoptera ; from Oxford ; and 20 Coleoptera ; from Nigeria.

Mr. E. C. Chubb, Durban Museum :—47 Diptera ; from Natal.

Prof. T. D. A. Cockerell :—2 *Tabanus*, 3 other Diptera, 195 Coleoptera, 4 Parasitic Hymenoptera, 25 other Hymenoptera, 58 Lepidoptera, 52 Rhynchota, 32 Orthoptera, and 12 Odonata ; from Siam.

Commercial Museum, Amsterdam :—3 Parasitic Hymenoptera ; from Sumatra.

Mrs. Connal :—7 Siphonaptera, 678 Culicidae, 320 Culicid larvae, 231 Tabanidae, 138 *Glossina*, 3 other Diptera, 13 Ticks, and 8 Mites ; from Lagos, Nigeria.

Mr. G. H. Corbett, Government Entomologist :—62 Diptera, 51 Coleoptera, 297 Parasitic Hymenoptera and a number of Braconid cocoons, 6 other Hymenoptera, 65 Lepidoptera, 41 Rhynchota, and 3 Orthoptera ; from the Malay Peninsula.

Mr. G. S. Cotterell, Assistant Entomologist :—15 Diptera, 19 Coleoptera, 4 Parasitic Hymenoptera, 60 Formicidae, 7 Lepidoptera, 83 Isoptera, 10 species of Coccidae, and 9 other Rhynchota ; from the Gold Coast, &c.

Mr. A. Cuthbertson : 2 *Lyperosia*, 34 other Diptera, 10 Coleoptera, 6 Parasitic Hymenoptera, and 5 Rhynchota ; from Southern Rhodesia.

Director General of Agriculture, Morocco :—56 Orthoptera ; from Morocco.

Mr. P. R. Dupont :—1 species of Coccidae and 1 species of Fungus ; from the Seychelles.

Dr. H. S. Evans :—2 Culicidae, 4 other Diptera, 488 Coleoptera, 3 Hymenoptera, and 2 Orthoptera ; from Northern Rhodesia.

Mr. T. B. Fletcher, Imperial Entomologist :—4 Parasitic Hymenoptera ; from India.

Mr. José Pinto da Fonseca :—69 Curculionidae ; from Brazil.

Mr. C. Franssen :—4 Chalcididae and 7 Lepidoptera ; from Java.

Mr. J. G. H. Frew :—266 *Glossina* ; from Sierra Leone.

Mr. J. C. M. Gardner, Systematic Entomologist :—36 Parasitic Hymenoptera ; from the United Provinces, India.

Mr. B. A. R. Gater, Medical Entomologist :—23 Culicidae ; from the Federated Malay States.

Mr. F. D. Golding, Government Entomologist :—41 Coleoptera, 4 Lepidoptera, 29 Rhynchota, and 3 Orthoptera ; from Southern Nigeria.

Government Entomologist, Coimbatore :—2 Coleoptera and 4 larvae, 14 Parasitic Hymenoptera, 10 Lepidoptera, 7 Rhynchota, and 5 Orthoptera ; from South India.

Mr. W. Greenwood :—38 Diptera, 7 Coleoptera, 81 Lepidoptera, 3 Aphidae, 5 other Rhynchota, 18 Psocidae, and 2 Trichoptera ; from the Fiji Islands.

Mr. G. L. R. Hancock, Assistant Entomologist :—919 Coleoptera, 38 Parasitic Hymenoptera, 19 other Hymenoptera, 222 Lepidoptera, 7 Rhynchota, 68 Planipennia, 4 Ephemeridae, and 11 Trichoptera ; from Uganda.

Dr. F. G. Holdaway :—27 Coleoptera ; from France.

Dr. J. C. Hutson, Government Entomologist :—93 Coleoptera, 68 Lepidoptera and 3 early stages ; from Ceylon.

Indian Museum, Calcutta :—273 Orthoptera ; from India.

Inspector General of Agriculture, Baghdad :—13 Mites ; from Iraq.

Mr. F. P. Jepson, Assistant Entomologist :—540 Isoptera ; from Ceylon.

Prof. C. R. Kellogg :—5 *Tabanus*, 3 Hippoboscidae, 72 other Diptera, 31 Coleoptera, 53 Parasitic Hymenoptera, 25 other Hymenoptera, 41 Rhynchota, and 5 Orthoptera ; from China.

Mr. J. W. McHardy :—45 Culicidae and 2 slide preparations ; from Tanganyika Territory.

Dr. C. A. Marelli : —105 Orthoptera ; from the Argentine Republic.

Mr. J. E. M. Mellor :—23 Hymenoptera ; from Egypt.

Mr. H. M. Morris, Government Entomologist :—32 Orthoptera ; from Cyprus.

Mr. J. Muggeridge, Government Entomologist :—6 Diptera and 6 Parasitic Hymenoptera ; from New Zealand.

Mr. R. W. Mungomery, Assistant Entomologist :—18 Diptera, 4 Coleoptera, and 25 Rhynchota ; from Queensland.

Mr. H. K. Munro :—5 Trypetidae ; from South Africa.

Musée du Congo Belge, Tervueren :—3 Rhynchota and 4 Ticks ; from the Belgian Congo.

Nairobi Museum :—51 Diptera, 26 Coleoptera, 114 Hymenoptera, and 2 Lepidoptera ; from Kenya Colony.

Mr. P. de Peyerimhoff :—8 Curculionidae ; from Algeria.

Mr. C. B. Phillips :—66 Culicidae and 100 Anoplura ; from Lagos, Nigeria.

Mr. A. H. Ritchie, Government Entomologist :—18 Diptera and 30 Parasitic Worms ; from Tanganyika Territory.

Dr. H. Schouteden :—70 Coleoptera ; from the Belgian Congo.

Mr. H. W. Simmonds, Government Entomologist :—11 Diptera, 2 Coleoptera, 8 Parasitic Hymenoptera, 3 other Hymenoptera, and 2 Trichoptera ; from the Fiji Islands.

Mr. S. H. Skaife :—196 Orthoptera ; from South Africa.

Mr. C. Smee, Government Entomologist :—37 Diptera, 7 Coleoptera, 66 Parasitic Hymenoptera, 34 other Hymenoptera, 20 Lepidoptera, 2 species of Coccidae, 5 species of Aphidae, 50 Psyllidae, 17 other Rhynchota, and 3 Parasitic Worms and their hosts ; from Nyasaland.

Dr. P. Tchorbadjiev :—3 Coleoptera and 62 Lepidoptera ; from Bulgaria.

Mr. A. Théry :—2 Orthoptera ; from Morocco.

Mr. H. P. Thomasset : —6 Culicidae, 3 Tabanidae, 61 other Diptera, 182 Coleoptera, 5 Parasitic Hymenoptera, 44 other Hymenoptera, 70 Lepidoptera, 70 Rhynchota, 42 Orthoptera, and 15 Anoplura ; from Natal.

Mr. F. W. Urich :—28 Culicidae ; from Venezuela ; and 11 other Diptera ; from Trinidad.

Wellcome Tropical Research Laboratories, Khartoum : —127 Culicidae, 29 Tabanidae, 37 other Diptera, 44 Coleoptera, 26 Parasitic Hymenoptera, 117 Lepidoptera, and 18 species of Coccidae ; from the Sudan.

Mr. C. B. Williams :—55 Orthoptera ; from Tanganyika Territory.

Mr. B. Zolotarevsky :—83 Coleoptera, 84 Hymenoptera, 3 Rhynchota, and 1,260 Orthoptera ; from Madagascar.

# A NEW SPECIES OF *BRYOCOROPSIS* (HEM. CAPSID.) ON CACAO IN FERNANDO PÓO.

By W. E. China.

**Bryocoropsis cotterelli,** sp. n.

*Colour.*—Blackish-brown, with the head, anterior lateral margins of pronotum, sides of the scutellum, sternum, venter, and legs, ferruginous brown. Hemielytra blackish-brown, with a large irregular area at apex of corium, pale yellowish-hyaline, and a small round spot below the middle of the embolium, another at base of corium, one on disc of corium, and some obscure markings on clavus, ochreous; membrane semi-opaque, blackish-grey with a dirty whitish bilobed spot below apex of cuneus

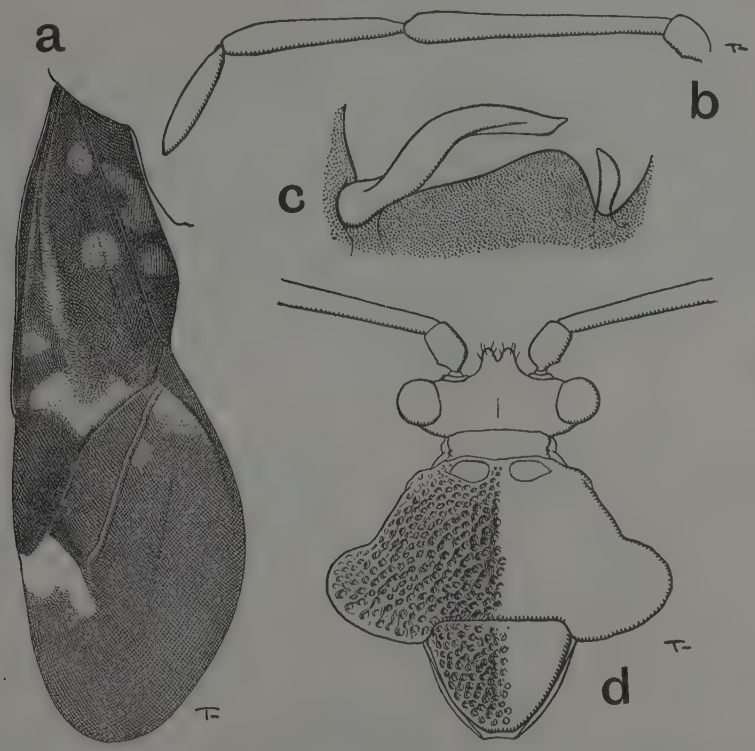



Fig. 1. *Bryocoropsis cotterelli*, sp. n.: *a*, hemielytron; *b*, antenna; *c*, genital claspers (parameres), terminal view; *d*, head, pronotum and scutellum, dorsal view.

between basal cell and the costal margin. Antennae black, the basal segment tinted with ferruginous brown. Rostrum brown with apex brownish-black. Hind tibiae tinted with black along outer side.

*Structure.*—Head (fig. 1, *d*) nearly twice as broad across eyes as pronotal collar (38:20), the vertex with two short apically projecting divergent processes as in *Sahlbergella singularis*, Hagl.; 1st segment of antenna (fig. 1, *b*) very short, barely

(5523) Wt P5/3521 1,100 10/29 H & Sp Gp 52

as broad as long (7:9) ; 2nd segment the longest, six times the length of the 1st, distinctly incrassate towards the apex ; 3rd segment about four times the length of 1st, distinctly incrassate, thickest just before apex ; 4th segment fusiform ; relative length of segments 9 : 55 : 35 : 24 ; rostrum extending to hind coxae, with relative length of segments 8 : 12 : 10 : 14. Pronotum (fig. 1, *d*) much less than twice as broad as long (67 : 41), the pronotal collar rather long, the humeral lobes narrower than in typical *Odoniella* spp. Scutellum (fig. 1, *d*) short, moderately inflated but not overlapping the inner margin of the clavus. Punctation of the pronotum and scutellum stronger and less regular than in *O. apicalis*. Cuneus long and narrow, not dilated as in *Sahlbergella*. Basal cell of membrane (fig. 1, *a*) strongly angulate posteriorly, the angle extending posteriorly beyond the apex of the cuneus. Pubescence of hemielytra finer and shorter than in *O. apicalis*. Abdomen moderately dilated but not so much as in typical species of *Odoniella*. Male genitalia figured.

*Length*, 5·5 mm. ; breadth across humeral lobes, 2·3 mm.

Fernando Póo : 2 ♂♂ (including type) bred from nymphs taken in company with nymphs of *Sahlbergella singularis* on cacao, September, 1928 (*G. S. Cotterell*).

The structure of the antennae and of the twin processes on the vertex in this genus is similar to that in *Sahlbergella*, but in the structure of the eyes, pronotum, and scutellum it is much more closely allied to *Odoniella*. A study of the male genitalia shows no striking generic difference between *Odoniella* and *Sahlbergella*. *B. cotterelli* differs from *B. laticollis*, Schum. (Sitzungsber. Ges. Naturf. Freunde, Berlin, 1917, p. 453), described from Spanish Guinea, in the colour of corium and femora, but Schumacher's description is so meagre that it is impossible to decide definitely on the identity of his species without seeing his type specimen.

# ON THREE NEW CHALCIDOID PARASITES OF *PLATYEDRA*.

By Ch. Ferrière, D.Sc.,
*Senior Assistant, Imperial Bureau of Entomology.*

Among several parasites received by the Imperial Bureau of Entomology from different countries, the following three parasites and hyperparasites of the pink boll-worm, *Platyedra gossypiella*, Saund., proved to be new and are described here as they may be of interest in the biological control of this cotton pest.

Together with one of these parasites, we received from the British Sudan another species which was labelled: "Bred from American cotton seeds grown in Ugud Wad.—Probably parasite on resting larva of *Platyedra gossypiella*." Other specimens, received later, had the labels: "Taken dead in cotton seed.—Parasitic on pink boll-worm." This parasite proved to be an American species, namely *Microdontomerus anthonomi*, Crawford (Fam. Torymidae), a parasite in the U.S.A. of *Anthonomus grandis*, Boh., the cotton boll-weevil, and of some other seed-beetles (*Bruchus*, *Anthribus*). Imported into the British Sudan with cotton seeds, it has probably nothing to do with *Platyedra*.

The types of the three new species have been deposited in the British Museum.

## Family Chalcididae.

**Brachymeria fijiensis,** sp.n. (fig. 1).

♀♂. Body black. Antennae dark, with the end slightly reddish. Tegulae yellow. Legs red with the coxae black, and the knees, the basis and end of the tibiae and the tarsi yellow; the hind femora are only somewhat yellow at the tip; the hind tibiae have the basal third and a large spot at the outer part of the end yellow. The males have the legs more variegated with black; the middle of the femora and of the tibiae are largely black with the other parts red.

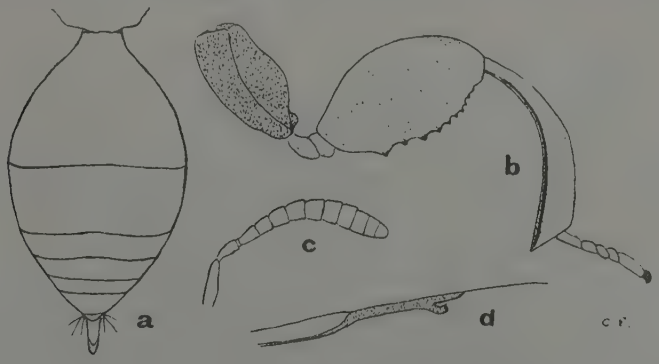



Fig. 1. *Brachymeria fijiensis*, sp. n., ♀: *a*, abdomen; *b*, hind leg; *c*, antenna; *d*, veins of forewing.

♀. *Head* shagreened, dull, with large, scattered, not very deep punctures. Face and cheeks covered with short white hairs. Antennal furrow smooth with margins slightly carinated, the upper part reaching a little below the front ocellus; the distance between the posterior ocelli about four times as great as their distance from the border of the eyes. Cheeks as long as the breadth of the eyes, with a longitudinal carina from the basis of the mandibles which turns behind the eyes

before reaching them. Antennae short, thick, with 13 joints ; scape not reaching the front ocellus, as long as the 4 following joints together ; pedicellus rounded, 1·5 times as long as broad ; one small annellus ; 1st joint of funicle a little longer than broad, the 2nd quadrate, the following gradually shorter and transverse ; club about as long as the two preceding joints together, rounded at tip, the last joint very small. *Thorax* finely shagreened, with large punctures rather regularly placed, this punctation somewhat thicker and more scattered on the scutellum than on the mesonotum. Mesopleurae smooth. Scutellum rounded behind, without teeth. Propodeon roughly reticulated. *Wings* hyaline ; marginal vein about twice the length of the submarginal ; the stigmal vein very short and thick ; the post-marginal vein twice as long as the stigmal and the marginal 2·5 times as long as the post-marginal. *Legs* with the hind femora finely shagreened and punctured, dull ; the hind tarsi short, with the 1st joint not or little longer than the 2nd, and the 5th very large, almost as long as the three preceding joints together. *Abdomen* oval, a little shorter than the thorax, sharply pointed at apex, the last segment being very narrow and longer than broad. All segments smooth and shining, very faintly shagreened from the 4th ; the 2nd and 3rd indistinctly sculptured on the sides only.

♂. Very similar to the female, the antennae only a little thicker, and the abdomen shorter, oval, more distinctly shagreened from the 2nd segment on.

*Length*, ♀ 4·2 mm., ♂ 3·5 mm.

Fiji Is. : Sigatoka, 2 ♀♀, 3 ♂♂, 3.ii.27 (*type*), viii.27, 31.viii.27 (*H. W. Simmonds*).

Two other species of *Brachymeria* have been obtained from pupae of *Platyedra gossypiella : B. obscurata*, Walker, in Hawaii and *B. olethrius*, Waterston, in Africa. The first of these species, which is widely distributed in South-East Asia, is parasitic upon many other Lepidoptera, including also *Sylepta derogata* in the Philippine Islands. It differs from our species specially through the form of the scutellum, which is posteriorly emarginated with two teeth, through the abdomen, which is less pointed and is distinctly punctured at the basis of the 2nd segment, and through the coloration of the legs.

## Family Eurytomidae.

**Eurytoma braconidis,** sp. n. (fig. 2).

♀♂. Body black. Antennae brownish, the flagellum covered with white hairs. Legs black, with the knees, the end of the tibiae and the tarsi yellow ; the tibiae are generally all dark brown with only base and tip yellow, but the anterior tibiae, especially in the males, may be more reddish-yellow with a brown longitudinal band in front. The wing-veins are very clear yellow, the marginal vein almost white.

♀. *Head* roughly punctured ; face covered with white hairs and with fine striae converging to the mouth, the central carina, between the clypeus and the antennal furrow, stronger. The antennal furrow rather deep, bordered by a carina and reaching just below the front ocellus. Vertex relatively broad, the ocelli forming a low triangle, the lateral nearer to the eyes than to the front ocellus. Cheeks shorter than half the length of the eyes, finely punctured. Mandibles with 4 short teeth. Antennae inserted in the middle of the face ; scape short, cylindrical, not reaching to the front ocellus ; pedicellus rounded, shorter than long ; annelli very small ; the 1st joint of funicle the largest, 1·5 times as long as broad ; 2nd not or very little longer than broad ; the following joints more rounded, as long as broad, almost petiolated ; club elongate, pointed, longer than the two preceding joints together. *Thorax* strongly punctured, but the punctation not deep, covered with fine white ciliae. Mesopleurae more finely sculptured. Mesosternum with a rather strong median longitudinal furrow, the posterior margin not protruding. Propodeon broadly concave in the middle, the concavity as broad as long and finely punctured,

much more finely than the rest of the propodeon. *Wings* broad, whitish ; the marginal nerve about 1·3 times as long as the stigmal vein ; postmarginal vein slightly shorter than the marginal vein. *Legs* normal ; coxae without teeth or plates ; the hind coxae thick and roughly punctured. *Abdomen* smooth, as long as the thorax, compressed from the sides ; petiolus short, transverse, the following joints all about the same length, only the 4th a little longer than the 3rd ; pygidium large, pointed ; valvae protruding a little behind the end of the abdomen.

♂. Smaller, but the structure the same as the female. Antennae elongate ; pedicellus small, rounded ; joints of funicle strongly nodulose, the 1st the longest, the following a little longer than broad ; each joint is produced into a thin petiole which is about twice as long as thick ; between the 5th joint and the club the contraction is equally strong, but the petiole is very short, punctiform ; club without any contraction between the joints ; hairs in two regular circles on each joint, on the funicle being twice as long as the greatest breadth of the joints, on the club shorter. Abdomen small, seen from the side rounded, with the petiolus as long as the hind coxae.

*Length*, ♀ 2·3–3·0 mm., ♂ 2 mm.

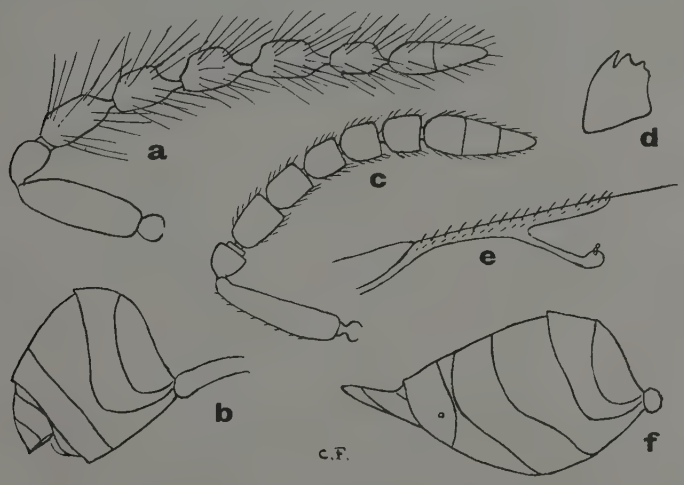



Fig. 2. *Eurytoma braconidis*, sp. n. : *a*, antenna, and *b*, abdomen, of ♂ ; *c*, antenna, *d*, mandible, *e*, veins of forewing, and *f*, abdomen, of ♀.

Uganda : Kampala, 3 ♀♀, 2.ii.1926 (*G. L. R. Hancock*). Tanganyika Territory : Morogoro, 9 ♀♀, 1 ♂ (*A. H. Ritchie*). British Sudan : Zeidab, 1 ♀, 4.vii.1928 (*J. W. Cowland*).

The series from Uganda is labelled " Hyperparasite on Braconid *ex Platyedra* sp." ; this Braconid has since been described as *Microbracon hancocki* by Wilkinson (1928). Mr. Ritchie's series is labelled " Hyperparasite," while the specimen from the Sudan is labelled " Hyperparasite of *Diparopsis castanea*."

This *Eurytoma* seems to be distributed throughout East Africa as a hyperparasite, living upon Braconid parasites of moths. It is closely related to the European *Eurytoma appendigaster*, Boh., another hyperparasite, but may be distinguished by the following characters :—

*E. appendigaster*, Boh. Thorax strongly punctate ; the propodeon with the median concavity rugulose, as the rest of the segment. Face rugulose, punctate.

Antennae with the joints of the funicle longer than broad. Fourth abdominal segment twice as long as the 3rd. Male with the small petioles between the joints of the funicle and between the funicle and the club more than twice as long as broad, and with the petiole of the abdomen longer than the hind coxae. Nervures of the wing pale brown.

*E. braconidis*, sp. n. Thorax strongly punctate, but the points not so deep; propodeon with the concave median part finely punctate. Face with fine divergent striae. Antennae with the joints of the funicle as long as broad, except the first. Fourth abdominal segment a little longer than the 3rd. Male with the petioles between the joints of the funicle less than twice as long as broad, and with the abdominal petiole not longer than the hind coxae. Nervures of the wing whitish.

## Family Elasmidae.

**Elasmus johnstoni**, sp. n. (fig. 3).

♀♂. Body entirely black, with greenish shine, sometimes partly bluish; abdomen aeneous, shining green at the base. Antennae brown, or sometimes reddish, the scape clearer. Legs dark, the trochanters, the tip of the anterior femora, the anterior

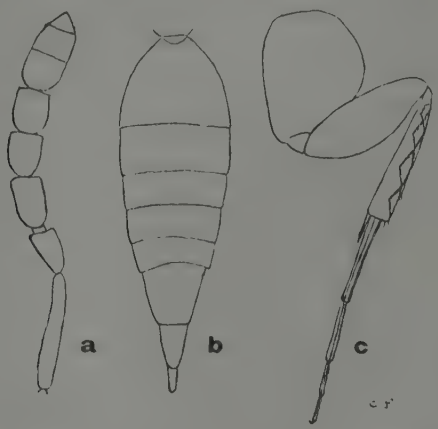



Fig. 3. *Elasmus johnstoni*, sp. n., ♀: *a*, antenna; *b*, abdomen; *c*, hind leg.

tibiae, the base and tip of the middle and posterior tibiae and the tarsi clear yellow; on the hind tibiae the dark coloration appears in the form of a more or less conspicuous brown ring beyond the middle.

♀. *Head* as broad as the thorax, with the frontal punctation rather strong, but not close. Antennae with the scape about as long as the two following joints together; pedicellus elongate, a little shorter than the 2nd joint of the funicle; the 1st joint of the funicle nearly twice as long as broad, the 2nd and the 3rd joints shorter, about 1·5 times as long as broad; club a little broader, and as long as the two preceding joints together. *Thorax* with the mesonotum broader than long, covered with dark ciliae; scutellum finely shagreened; postscutellum triangular, with a translucid border, projecting over the propodeon; propodeon smooth and shining. *Wings* hyaline, ciliated from the base, with a hairless part near the posterior margin; at rest they reach a little beyond the tip of the abdomen. *Legs* with the femora and hind coxae finely striate; on the hind tibiae the hairs form regular elongate

lozenges. *Abdomen* elongate, longer than head and thorax together; all segments short, transverse, except the 1st and the 6th, which are a little longer than broad. Ovipositor slightly protruding.

♂. Very similar to the female, but smaller, and the abdomen shorter than the thorax. The antennae have a short scape, a triangular pedicellus, as long as broad, the first three funicular joints short, each bearing a long and slender branch reaching to the base of the scape, the 4th joint much elongate and the club about as long as three-fourths of the 4th joint; the funicular joints and the branches are covered with long hairs.

*Length*, ♀ 2·1–2·5 mm., ♂ 1·5–1·6 mm.

BRITISH SUDAN: Wad Medani, 1 ♀, 15.iv.1927 (*H. B. Johnston*). INDIA: Karnal, Punjab, 2 ♂♂, 29.ix.1923 (*U. Bahadur*).

The above specimens were all bred from *Platyedra gossypiella*, while others, both females and males, have been obtained in the Sudan from the larvae of *Earias insulana*, and from larvae in bolls of *Abutilon* sp.

This species may be distinguished by the dark coloration of its body and legs, by the hind tibiae being clear with a brown ring below the middle, and by the form of antennae and abdomen. I have compared it with all the known African, European and Asiatic species, as well as with many species still undescribed, and it is intended to publish shortly a study on *Elasmus* spp., in order to facilitate the distinction of the different forms.

# PHASES OF LOCUSTS AND THEIR INTERRELATIONS.

By B. P. Uvarov,

*Senior Assistant, Imperial Bureau of Entomology,*

and

B. N. Zolotarevsky,

*Chef du Bureau Central de lutte contre les sauterelles, Madagascar.*

The theory of phases of locusts put forward as a working hypothesis by the senior author (Uvarov, 1921) has led, as might have been expected, to further researches in that direction, but the results obtained have been in some cases apparently contradictory. A summary of the work done on these phases has been published recently in a book (Uvarov, 1928), and we do not propose to repeat it here, the purpose of the present joint paper being to discuss very briefly certain aspects of the problem in the light of new observations made by Predtechensky (1928) in Russia and by the junior author in Madagascar.

The apparent contradictions in the conclusions reached by several workers on locust phases are due partly to the theory in its original form having been much too diagrammatic, and partly to the inability of some entomologists to understand fully its main principles.

The original theory recognised the fact of the existence in swarming locusts of two extreme forms, or phases, connected by a continuous series of transitional ones. The phases differ from each other in morphological and colour characters, on the one hand, and in biological peculiarities (mainly behaviour), on the other. Biological differences are, of course, of primary importance, but the conception of phases in the minds of most workers remains mainly morphological, and they are trying to find absolute characters in the structure and colour that would enable one to refer each specimen to a definite phase. It will be shown by us that this may be possible only after detailed studies of the species in a given locality.

## Standard Nomenclature of Locust Phases.

The morphological conception of phases led naturally to designating each phase by the name under which that form of the species was first described. In this way, the swarming phase of *Locusta migratoria*, L., obtained the name ph. *migratoria*, L., and the solitary phase has been called ph. *danica*, L., having been described as *Locusta danica*, L. Analogous historical names have been applied to phases of other locust species, and the nomenclature of phases became unnecessarily complicated. Attempts to find a way out have been made by Plotnikov (1927) and Predtechensky (1928), who suggested the use of the names *dispersa* and *solitaria* for the solitary and the name *accumulata* for the gregarious phase of *Locusta migratoria*. Plotnikov's conception of phases was, however, erroneous (see Uvarov, 1928), and the scheme of the interrelations of phases given by Predtechensky is both incomplete and insufficiently clear. The present writers believe, therefore, that it would be useful to propose a scheme of nomenclature of phases which would be applicable to all species of locusts. This nomenclature should be rational, that is, uniform for all species and not bound by the formal laws of priority, while permitting the designation by a word of the actual biological status (phase) of the species in a given locality and at a given moment.*

* Such a procedure is perfectly legitimate, since there is a definite tendency in modern entomology to discard the application of formal rules of nomenclature to all forms below subspecific rank.

Three unstable biological states of a locust may be distinguished, viz., solitary, gregarious, and transitional between the two, and the following names are proposed here for their designation.

(1) *Phasis solitaria.* To be applied to the extreme form by which the species is represented in a given locality when only isolated individuals are present and no swarms exist or have existed within at least one preceding generation.

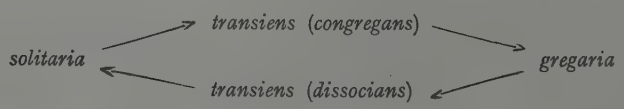
(2) *Phasis transiens.* To be applied to the form occurring in a given locality when the species is on the increase and its individuals are beginning to form loose aggregations, or on the decrease, and the swarms are becoming loose and tend to scatter either in the hopper stage or shortly after becoming adult (Zolotarevsky, 1929).

It must be quite clearly understood that the name is not applied to any definite form, but to a continuous series of transitional forms between the two extreme phases ; such a series may be observed during the transformation of one phase into another. Thus, ph. *transiens* may be represented by forms morphologically and biologically quite close either to ph. *solitaria* or to ph. *gregaria*, into both of which the series merges imperceptibly.

The term ph. *transiens* must be replaced by ph. *congregans* in cases in which the transformation is known to be in the direction from the solitary to the gregarious phase, and by ph. *dissocians* when the change is in the opposite direction ; this it is impossible to estimate unless a continuous series of observations has been carried out throughout several generations, and the name *transiens* has to be used in all doubtful cases. It may be mentioned that certain observations by the junior author tend to show that the phases *dissocians* and *congregans*, while very similar to one another, may be distinguished by some minor details of morphology and coloration, but this point will be discussed more fully elsewhere.

(3) *Phasis gregaria.* To be applied to the extreme form to which belongs the bulk of individuals of the species in a given locality, when it is forming dense and large, emigrating swarms.

The general scheme of the cyclic interrelations between all phases of a locust may be represented as follows :—




**Phases and Geographical Forms of Locusta migratoria.**

Predtechensky (1928) pointed out and proved by measurements that the Migratory locust is represented in Central Russia by a form that differs from the locust inhabitating more southern areas, viz., the regions of the Caspian and Aral Seas. The differences are very small in the case of the solitary phases, but the gregarious phase of the northern form differs from that of the southern one very considerably. In the southern form the gregarious phase is strikingly distinct from the solitary one, while in the northern form the extreme gregarious phase is much nearer to the solitary phase and corresponds morphologically only to a transitional phase of the southern form.

The data given by Predtechensky show that the two forms must be regarded as geographical subspecies of *L. migratoria*, L. He reserves the name *L. migratoria migratoria* for the southern subspecies, and for the northern the name *L. migratoria danica*, L., is suggested, since this name was originally used for an insect from Denmark, which the author thought to be referable to the same subspecies as the

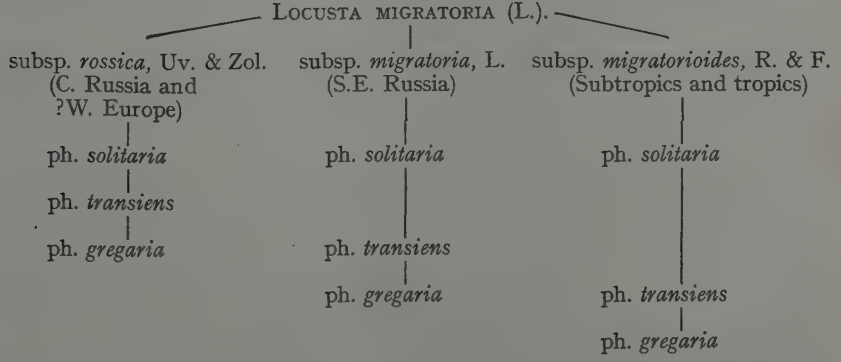
Central Russian locust. While there is no doubt that the latter is sufficiently characterised to receive subspecific rank, the present authors are not at all convinced that it is identical with the Linnean *danica*. Danish representatives of *Locusta* have never been studied by any one. However, two males from Jutland, kindly sent to us by Dr. Esben-Petersen proved to belong to the true *migratoria* (gregarious phase), agreeing in all measurements and other characters with those given by Predtechensky for the southern subspecies.

Thus, a name is wanted for the Central Russian locust, and we propose to call it *Locusta migratoria* **rossica,** subsp. n. The description and measurements of all phases of this subspecies are given by Predtechensky (*l.c.* pp. 176–181, figs. 4 : 1, 5, 7, 9, 15) ; the typical locality is the north-west part of the Spassky district, Penza province, Central Russia. The type is a male of ph. *gregaria* (termed *accumulata* by Predtechensky) ; a female of the same phase and two males and two females of ph. *solitaria* are considered paratypes. A pair of paratypes (solitary phase) are preserved in the British Museum, other paratypes and the type are in the Zoological Museum, Russian Academy of Sciences, Leningrad.

It is probable that the same subspecies occurs in at least certain localities of Western Europe (Schaffhausen on the Rhine, Wallis in Switzerland), but a definite conclusion can be reached only after detailed studies of mass material.

Recent studies of the junior author in Madagascar have proved that the form of *L. migratoria* occurring there is very similar in its solitary phase to the respective phases of *L. migratoria migratoria* and *L. migratoria rossica,* but the gregarious phase of the Madagascar locust develops still further than in *L. m. migratoria,* so that a phase morphologically analogous to the gregarious phase of the latter represents in Madagascar only a transitional phase (ph. *transiens*) of the local locust. It is clear thus that *L. migratoria* of Madagascar belongs to a distinct subspecies, and the name *L. m. migratorioides,* Rch. & Frm., should be applied to it, since the Madagascar specimens agree with the description and figure of the latter (known originally from Abyssinia) and with specimens from the African continent.

The interrelations of the three known subspecies of *L. migratoria* and of their phases may be more clearly understood if represented graphically as follows :—




(It should be clear from the preceding discussion that ph. *solitaria* of all three subspecies corresponds to what has been called before ph. *danica,* L. ; *L. migratoria* ph. *gregaria* corresponds to the former ph. *migratoria* ; and *L. migratorioides* ph. *gregaria* to the former ph. *migratorioides.*)

The vertical columns in the scheme represent each a series of biological phases of the respective subspecies, while the horizontal lines indicate the morphological

similarity of phases of different subspecies. The subspecies have, of course, no absolute differentiating characters, since they are connected by transitional forms in the intermediate geographical areas, but their relative differences are appreciable as has been shown by Fredtchensky in the case of *L. m. migratoria* and *L. m. danica*, and will be shown for *L. m. migratorioides* by the junior author in a forthcoming paper. As a species, however, *L. migratoria*, in spite of its very considerable geographical and phase variation, remains a definite unit.

There is little doubt that further research in other countries will necessitate the separation of other geographical subspecies of *L. migratoria*, but we believe that each one of them, when studied fully with all its phases, will find its place in the above scheme. It is possible that some of the subspecies may be less polymorphic than others, and there are apparently countries where the species is always represented only by the solitary phase, but this again will not affect the scheme.

The scheme demonstrates clearly that it would be futile to attempt to identify phases of locusts on the bases of the morphological and colour characters of the specimens. Each subspecies must be studied in detail in a given locality throughout at least one full cycle of transformation from one extreme phase into the other and back again; then, and then only, morphological and colour characters of each phase can be established, but these characters will be applicable only in this particular locality and must not be applied elsewhere, however similar the insects may appear to be, in the absence of detailed studies.

This point of view, elucidated by the example of *L. migratoria*, should be followed in studies of other species of locusts.

## Phases of other Locusts.

Phases of other locusts have been discussed recently in the book by the senior author (Uvarov, 1928), but the phases have been designated there by their priority names, which must now be replaced by the standard names. They are given below, with the old formal names in the brackets :—

The desert locust, *Schistocerca gregaria*, Forsk.

ph. *gregaria* (*gregaria*, Forsk.)
ph. *solitaria* (*flaviventris*, Burm.).

The South American locust, *Schistocerca paranensis*, Burm.

ph. *gregaria* (*paranensis*, Burm.)
ph. *solitaria* (? *americana*, F.).

The brown locust, *Locustana pardalina*, Walk.

ph. *gregaria* (*pardalina*, Walk.)
ph. *solitaria* (*solitaria*, Uv.).

The red locust, *Nomadacris septemfasciata*, Serv.

ph. *gregaria* (*septemfasciata*, Serv.)
ph. *solitaria* (*cosnguistata*, Luc.).

The Moroccan locust, *Dociostaurus maroccanus*, Thnbg.

ph. *gregaria* (*maroccanus*, Thnbg.)
ph. *transiens* (*degeneratus*, Baranov).

The lesser migratory grasshopper, or Rocky Mountain locust, *Melanoplus mexicanus atlanis*, Riley

ph. *gregaria* (*spretus*, Walsh)
ph. *solitaria* (*atlantis*, Riley).

*References.*

PLOTNIKOV, V. I. *Locusta* (*Pachytylus*) *migratoria*, L., and *danica*, L., as independent forms and their derivatives .[In Russian.]—Tashkent, 33 pp., 12 figs., 1927.

PREDTECHENSKY, S. A. *Locusta migratoria*, L., in Central Russia. [In Russian.]—Reports Bureau Appl. Entom. Leningrad, iii, pp. 113–199, 5 figs., 29 tables, 1928.

UVAROV, B. P. A revision of the genus *Locusta*, L. (*Pachytylus*, Fieb.), with a new theory as to the periodicity and migrations of locusts.—Bull. Ent. Res., xii, pp. 135–163, 8 figs., 1921.

UVAROV, B. P. Locusts and grasshoppers.—London, Imperial Bureau of Entomology, 352 pp., 118 figs., 9 pls., 1 map, 1928.

ZOLOTAREVSKY, B. Sur le comportement de *Locusta migratoria*, L. subsp. *migratorioides*—Rch. et Frm. phasis *transiens*.—C. R. Acad. Sci. France, t. 189, pp. 131–133. Paris, 1929.

# NEW SPECIES OF NYSIUS (*HEM., LYGAEID.*) FROM SOUTH AFRICA.

By J. W. Evans, B.A.,

*Assistant Entomologist, Commonwealth Council of Scientific and Industrial Research.*

In the few published accounts of insects belonging to the genus *Nysius* attacking crops in South Africa, the specific name of the Lygaeid concerned has always been given as *binotatus*, Germ., known locally as the common stinkvlieg, this species having been recorded as attacking not only fruit, potatoes and sunflower seed-heads,[1, 3], but also as being a household pest[2].

Three species of this genus have so far been described from South and West Africa* —*N. binotatus*, Germ., *N. albidus*, Dall., and *N. pallens*, Dall. I have examined the types, which are in the British Museum, and find that *pallens*, Dall., is synonymous with *binotatus*, Germ., the latter name being retained on the grounds of priority. Germar's description of *Nysius binotatus*[4] does not entirely correspond with the type, the general colour being given as grey (griseus), while it is actually a pale greenish yellow. However, the one morphological character given, " thorax narrowed towards the front," is of specific value and correct.

In the Museum collection are a number of specimens quite distinct from *binotatus*, Germ., and *albidus*, Dall. ; from these I have been able to separate three new species. All the descriptions I have seen of *Nysius* spp. have largely consisted of colour characters ; these by themselves are insufficient, on account of the variation in colour found in individuals of the same species, but the morphological differences though slight are constant. Hence, in addition to describing the three new species, I give below a redescription of *binotatus* and *albidus*, and an outline camera-lucida drawing of each species, each figure being drawn to the same scale.

The chief morphological characters of specific value in this genus are : the shape of the head, pronotum, and scutellum ; the length of the bucculae, and the 1st rostral joint ; the proportionate length of the antennal segments ; and the shape of the costal margin of the corium. Colour characters are made use of, but the only one of any real value is the general coloration given at the beginning of each description.

**Nysius binotatus,** Germ., 1837 (fig. 1, *a*).

General colour, very pale greenish yellow. Length, 3·25 mm. (from front of head to apex of wings).

*Head* pale reddish-brown, finely punctured, with a blackish longitudinal line on each side. Eyes pale chocolate brown. Antennae short, the 2nd joint being the longest and the terminal joint the shortest (with the exception of the proximal joint). The bucculae, which reach the base of the head, are of the same length as the 1st rostral joint. *Pronotum* pale greenish-yellow with shallow grey pits and a pale median longitudinal band ; anterior margin much narrower than the posterior one. *Scutellum* ochreous-brown, with dark brown pits, excepting for the central raised area, which is smooth and pale yellow. *Hemielytra* with corium and clavus pale-biscuit colour, the only dark markings being the three bars on the interior margin. Costal margin of the corium as in figure.

*Type*, male, from the Cape of Good Hope, in the collection of the British Museum (Drége Coll.). The type of *pallens*, Dall., is a female. Males of all the species in

* *N. novitius*, Dist., from the Transvaal is not included, since it belongs to the genus *Aphanus*, sub-family Aphaninae.

this genus are much smaller than the females. The figure was not made from the type, but is of a female insect, as are all those figured.

**Nysius albidus,** Dall., 1852 (fig. 1, *b*).

General colour, pale brown. Length, 2·75 mm. (from front of head to apex of wings).

*Head* reddish brown, with a black longitudinal line on each side ; tylus reddish brown. Eyes dark brown. Antennae dark brown, the 2nd joint being the longest and the 3rd the shortest (with the exception of the proximal joint). The bucculae, which nearly reach the base of the head, are shorter than the 1st rostral joint.

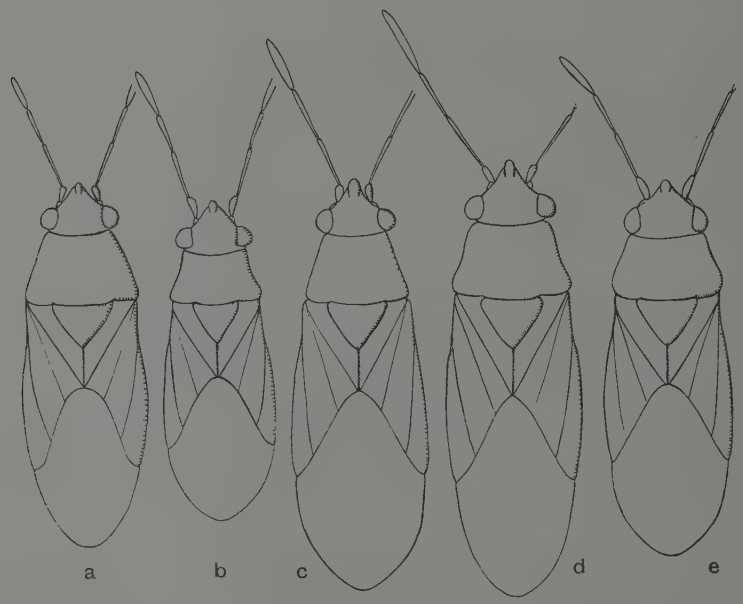



Fig. 1. Outlines of ♀♀ of : *a, Nysius binotatus,* Germ. ; *b, N. albidus,* Dall. ; *c, N. ståli,* sp. n. ; *d, N. pallidus,* sp. n. ; *e, N. natalensis,* sp. n.

*Pronotum* pale brown, the lateral margins markedly concave. *Hemielytra* with corium and clavus greyish-white, the veins having a few scattered dark bars. Costal margin of the corium as in figure.

*Type,* male, from Sierra Leone, in the collection of the British Museum.

**Nysius ståli,** sp. nov. (fig. 1, *c*).

General colour, dirty yellow to dark brown, with black markings. Length, 3·5 mm. (from front of head to apex of wings).

*Head* reddish-brown ; in addition to the black lateral margins there is a median black stripe. Tylus dirty yellow, edged with black, extending anteriorly well beyond the jugae. Eyes prominent, very dark brown. Antennae pale brown, the 2nd and 3rd segments being equal in length and shorter than the terminal segment.

The bucculae do not reach the base of the head, the 1st rostral joint extending beyond the limit of the bucculae. *Pronotum* dull buff, with irregular dark areas in front of the posterior margin, which is much wider than the anterior margin. *Scutellum* dark brown. *Hemielytra* with corium and clavus pale transparent yellow, the veins being slightly darker, and the interior margin having three dark bars. Costal margin of corium as in figure.

*Type*, female, from Weenen, Natal, in the collection of the British Museum (presented by the Imperial Bureau of Entomology).

**Nysius pallidus,** sp. nov. (fig. 1, *d*).

General colour, yellowish-buff. Length, 4·5 mm. (from front of head to apex of wings).

*Head* pale reddish-brown, the lateral margins being black, the tylus yellow. Eyes chocolate brown. Antennae long, having the terminal joint the longest and the 3rd joint the shortest (with the exception of the proximal segment). Bucculae short, not nearly reaching the base of the head; the 1st joint of the rostrum, although longer than the bucculae, also does not reach the base of the head. *Pronotum* pale yellow, with a slightly darker area in front of the posterior margin, in addition to the two transverse dark stripes (calli) found in all species of this genus. *Scutellum* yellowish-buff, excepting for the central area, which is black. *Hemielytra* with corium and clavus pale transparent yellow, the veins being slightly darker, and the interior margin pale brown with three dark bars. Costal margin of corium as in figure.

*Type*, female, from Mossel Bay, Cape Province, in the collection of the British Museum (presented by Mr. R. E. Turner).

**Nysius natalensis,** sp. nov. (fig. 1, e).

General colour, dark greyish brown. Length, 3·25 mm. (from front of head to apex of wings).

*Head* broad and short, reddish-brown, with lateral black stripes, the tylus pale, edged with black. Eyes dark chocolate brown. The terminal joint of the antennae is shorter than the 3rd or 2nd, the last named being the longest. Bucculae almost reaching the base of the head, extending beyond the end of the first rostral joint. *Pronotum* broad and short, pale brown with irregular dark brown areas. *Scutellum* brown, the raised central area being black. *Hemielytra* with corium and clavus greyish, the veins being buff with numerous dark bars, the interior margin of the corium having three dark bars.

*Type*, female, from Durban, in the collection of the British Museum.

*Further Notes.*

Stål's sub-genus, *Rhypodes*, erected in 1868 for *Nysius zealandicus*, Dall. (=*clavicornis*, Fabr., Syst. Rhyng., p. 201, 48, nec *clavicornis*, Fabr., tom. cit., p. 198, 32, which is a Coreid, *Strobilotoma typhaecornis*, Fabr.), will take priority over *Myersia*, Evans.[9] Fabricius gives Copenhagen as the locality of *Lygaeus clavicornis*, but Stål in Hem. Fab., i, p. 76, points out that the type is identical with *N. zealandicus*, Dall., and that Fabricius had probably confused New Zealand with Zealand, the island on which Copenhagen is situated.

In a key recently published to the genera included under *Nysius*, auctt.,[9] I omitted Stål's sub-genus *Macroparius*, type *Nysius graminicola*, Kol. It is defined as follows:— Bucculae percurrent, equally high throughout, extending posteriorly beyond the apex

of the first joint of the rostrum, and freely extending backwards in a lobe-like process. However, Oshanin in his Palaearctic Catalogue[12] states that the genus *Macroparius*, Stål=*Nysius*, Dall., so that the omission does not affect the key.

*References.*

(1–3) Departmental Activities: Entomology. J. Dept. Agric. Un. S. Afr., viii, no. 4, 1924, p. 358; x, no. 5, 1925, p. 379; xii, no. 3, 1926, p. 201.
(4) Germar, E. F. Silb. Rev. Ent., v, 1837, p. 138.
(5) Dallas, W. S. List of Hemiptera, pt. 2, 1852, p. 552.
(6) Stål, C. Hemiptera Fabriciana, 1, 1868, p. 76.
(7) Stål, C. Öfv. Vet. Akad. Förh., 1872, no. 7, p. 43.
(8) Stål, C. Enumeratio Hemipterorum, iv, 1874, pp. 119–122.
(9) Evans, J. W. Bull. Ent. Res., xix, 1929, pt. 4, pp. 351–354.
(10) Fabricius, J. C. Syst. Rhyng., 1803, p. 201.
(11) Oshanin, B. Verz. Pal. Hemipt., i, 1906, p. 261.

*Acknowledgment.*

I wish to acknowledge the assistance I have received in the preparation of this paper from Mr. W. E. China of the British Museum.

# NOTES ON AUSTRALIAN CULICIDAE (DIPT.).

By Frank H. Taylor,

*Entomologist, Australian Institute of Tropical Medicine, Townsville.*

(Plate XII.)

The writer some years ago described a mosquito under the name of *Dixomyia elegans*, the type of which remained unique until May, 1927, when a few adults, larvae and pupae were collected. The larvae and pupae were found in hoof-holes made by cattle on the edge of a swamp. The water in these holes contained a considerable amount of decaying vegetable matter and was comparatively clear. It was not examined for algae, except that both *Nitella* and *Chara* were noted as being absent. The B. D. H. Universal Indicator gave a colour change of greenish-yellow (7·0–7·5) in all samples of water tested for pH.

In addition to this species some females of a remarkably distinct one, *Mimomyia metallica* (Leic.), were bred from the above-mentioned series of larvae and pupae. An examination of the imago, also of the larval and pupal skins, led the writer to the conclusion that these specimens belonged to a species of *Ficalbia*, and drew up a description of this mosquito as a new species of *Ficalbia*, unfortunately overlooking Leicester's remark that "members of the genus *Mimomyia* sub-family Aedeomyina have many points in common with members of this genus [*Conopomyia*] . . . ." Edwards' recent paper on Malayan Nematocerous Diptera was also not available to him. Thanks, however, to the kindness of Mr. Edwards, to whom specimens were later submitted, the writer avoided adding further synonymy to this already over-burdened family.

The writer has held the opinion for some time that *Mimomyia* should be sunk as a synonym of *Ficalbia* on account of their close relationship, unaware of the fact that Dyar had made the statement (until so informed by Mr. Edwards).

**Ficalbia elegans** (Taylor) (Pl. xii, figs. 1, 4).

*Dixomyia elegans*, Taylor, Trans. Ent. Soc., 1913, p. 703 (1914).

*Etorleptiomyia elegans*, Taylor, Proc. Linn. Soc. N.S.W., xli, p. 573, 1916.

*Ficalbia elegans*( Taylor) Edwards, Bull. Ent. Res., xiv, p. 364, 1924.

♀. *Head* clothed with golden narrow-curved and upright-forked scales in front, with white upright-forked ones behind, black upright-forked ones on each side of these, a small patch of white flat scales, then a patch of black ones followed by another patch of white flat scales laterally; antennae dusky, basal lobe yellowish-brown apically covered with small white flat scales, basal half of second segment yellowish, covered with white flat scales, third segment about one quarter shorter than the second, all segments except the basal lobe densely covered with pale pubescence, verticillate hairs black; palpi about one-fourth the length of proboscis, covered with black scales, with a few pale ones in the middle, apices also white-scaled, apical segment swollen; clypeus black; proboscis with a prominent black basal band (about the length of the palpi), rest of proboscis mottled with black and white scales above, apical fourth swollen, its base with a prominent band of orange-coloured scales, labella reddish-brown with dense pale pubescence, the proximo-central quarter, ventrally, clothed with creamy-white scales.

*Thorax* covered with dense narrow-curved black scales and a broad stripe about half the width of the scutum posteriorly of golden ones, extending from the anterior margin almost to the level of the wing-roots, a few small patches of golden narrow-curved scales scattered among the black-scaled area on either side of the golden stripe;

a small patch of outstanding black, almost lanceolate, scales on either side of the wing-roots, a group of black setae at the wing-roots and a few golden narrow lanceolate scales at the posterior angles of the median stripe ; scutellum covered with black flat scales, a narrow bare area between the mid and outer lobes, and a small patch of moderately broad pale scales on the posterior margin of the lobes, particularly noticeable on the mid lobe.

*Abdomen* clothed with dusky brown scales with violet reflections in some lights, first segment with a fairly large patch of white scales, segments two, three and four with a small white, median spot, decreasing in size to the fourth, all segments with apical golden hairs, segments four to apex with prominent lateral patches of white scales ; basal half of venter white-scaled, apical half mostly white-scaled with apices of segments covered with dark brown scales.

*Legs* with the fourth and apical tarsal segments of fore and mid legs with narrow apical and basal banding, all the legs with conspicuous violet reflections.

*Wings* clothed with dark brown broad scales (somewhat resembling those of *Mansonioides* spp.) with numerous similar white ones disposed either singly or in patches on the veins, the median vein scales being about half the size of the lateral ones.

♂. Palpi about four-fifths the length of the proboscis, slender and slightly swollen apically, gently upturned at apex, the latter white-scaled with a black band immediately behind, about four times the width of the white-scaled area, their base with a similar black band, rest of palpi mottled with black and white scales ; antennae with basal lobe, penultimate and apical segments dusky brown and clothed as in the ♀, joints brown, plumes dense, brown. Ungues of fore and mid legs unequal, the larger with a small basal tooth. Side-piece of hypopygium conical, clasper uniform in width, except the base which appears bulbous (in side view this portion, about the basal third, gradually widens to about twice its width at the base), basal lobe with three bristles, the inner one the longest ; tenth sternites with three strongly chitinised teeth at the apex ; ninth tergites with two groups of seven bristles each, all of about the same length.

Larva. Head broader than long, clypeus yellowish brown, posterior half of the lateral chitinous plates dusky brown ; antennae not infuscate, except the apex which is faintly so, covered with colourless spicules, more numerous on the basal half, latero-median tuft with eight slightly plumose shafts, two long subapical hairs, two apical hairs, the shorter about one-fourth the length of the longer ; pre-clypeal spines brown, stout, moderately long ; pre-antennals (of Lang) short, composed of fourteen plumose shafts, inserted very slightly interior to the inner post-antennals, shafts of all three pairs of post-antennals long, reaching well beyond the anterior margin of the clypeus, shafts plumose, the outer with eleven, mid with four and the inner with six shafts. Thorax broad ; lateral tufts long, shafts plumose, fore and mid tufts each with a conspicuous internal spine at the base. Abdomen with long, plumose, lateral setae ; comb composed of seventeen small, fringed spines, arranged in a transverse row ; siphonal, subsiphonal and anal tufts with their shafts apparently all plumed ; siphon yellowish-brown, apex infuscated, base with a narrow black band, siphonic index about 7 : 1, the distal half gradually tapering to the extremity, a tuft of two moderately long hairs toward the base of the middle third, no pecten.

Pupa. The resting attitude of the living pupa is similar to that described by Senior-White. Trumpets infuscate, except the apical fourth which is pale yellowish-white, about one-third longer than the cephalothorax ; dendritic hairs on first abdominal segment obsolete, being represented by two pairs of simple setae ; sub-median setae of segment vii more than twice the length of segments viii and ix, each composed of three shafts, those on segments iii to vi similar but considerably shorter, segment viii with two small spines on its posterior angle, the inner spine slightly

smaller ; internal to these spines and mounted on a tubercle is a tuft of seven plumose hairs in the male, in the female this tuft is composed of six plumose hairs ; segment ix in the male ends in a single spine on the apical external angle, in the female this angle is bluntly rounded and has three spines, the middle one about half the length of the other two, the latter being of about the same length ; paddles long and narrow, with a pale brownish tint except on the apical third, midrib well developed, no terminal setae, fringe composed of tooth-like processes extending right round except at the base of the paddles, the processes increasing in size from the base to the apex.

QUEENSLAND : Townsville (*F. H. Taylor*).

The female has been somewhat fully redescribed as there are discrepancies in the original description.

There is, in the Institute collection, a series comprising the allotype ♂, 5 ♂♂ and 4 ♀♀ in addition to the original ♀ type, which is now useless as such owing to serious damage, and another ♀ has therefore been selected as a neotype. These eleven specimens were taken by the writer, both in the immature stages and as adults in the sweep net, ten of them being in perfect condition.

Through an unfortunate accident the sex of the larvae is unknown. There is, in the Institute collection, in addition to the two larval skins from which the description was made, another skin, believed to be that of the male, which exhibits differences from the other skins rendering the acquisition of further larvae desirable before describing it. This skin has the basal half of the antennae deeply infuscated and the spicules more prominent ; the head is more dusky and *inter alia* there are two prominent spines on the lower edge of the siphon.

**Mimomyia metallica,** Leic. (Pl. xii, figs. 2, 3, 5, 6).

QUEENSLAND : Townsville (*F. H. Taylor*).

LARVA. Head of ♂ with anterior margin of clypeus brown, also from the pre-antennals to the posterior margin of clypeus dark brown, rest of clypeus yellow ; apex and basal half of the lateral chitinous plates infuscate, remainder yellowish ; slightly more than the basal half of the antennae infuscate, spicules black, prominent, those between the sub-basal and sub-apical hairs brown and less prominent, sub-basal hairs infuscate, apparently six in number, plumose ; there are two long sub-apical hairs, about the same length, two apical hairs, the outer about half the length of the inner, and an outer apical spine ; in ♀ the head is yellowish-brown, the area from the pre-antennals to the posterior margin of the clypeus brownish-yellow ; posterior half of the lateral chitinous plates brownish-yellow, anterior half almost clear ; mental plate with nine teeth on each side of the large median one ; antennae not at all infuscate, base with a narrow yellowish ring, spicules clear, less numerous, somewhat longer and narrower than in ♂ ; in the latter the preclypeal spines black and stout, yellowish-brown in ♀ ; pre-antennals situated interior to the inner post-antennals, fairly long in ♂ and composed of four slightly plumose shafts, in ♀ there are about fifteen similar shafts of which five or six are stouter than the rest and also slightly plumose (the smaller ones are not plumose) ; the inner, mid and outer post-antennals with five, four and fifteen black plumose shafts respectively in ♂, in ♀ there are five, three and eleven brown plumose shafts respectively ; plumes denser in ♂ than in ♀. Thorax broad, lateral tufts long with a conspicuous external tooth and two smaller internal teeth at the base, shafts plumose. Abdominal lateral setae brown, long, plumose ; comb composed of 28 small fringed teeth, disposed in two irregular rows of 20 and 8 teeth respectively ; siphonal, subsiphonal and anal tufts of plumed hairs ; siphon yellow in both sexes with a narrow dark basal band, siphonic index about 5 : 1, slightly tapering to the apex ; hair-tuft slightly basal of the apex of the

basal half, composed of six fairly long hairs in the ♂, of two hairs in the ♀ ; pecten composed of three large simple teeth of about equal size and equidistant from one another, no pecten in the ♀.

Pupa. Respiratory trumpets very long, infuscate, except about the apical fourth, which is pale, tinged with yellow, the apex funnel-shaped and barely three times as wide as the base (17 : 7); dendritic tufts on segment i composed of eight branches, which themselves split up into two and sometimes three shafts ; submedian setae on segment vii composed of three pubescent hairs which are about the length of segment viii, those of segments v and vi similar and about the same length, those on segments ii, iii and iv composed of eight shafts and about the same length as those of the following segments respectively ; paddles about the length of segments vii and viii combined, broad, about 1·5 times as long as broad, the width measured about the middle ; midrib very prominent with a fairly broad shading of light brown on each side, apical fourth of paddle shaded light brown ; a short terminal seta, a narrow oblique basal black band, fringe commencing about the middle of the external margin and extending to the internal angle of the paddle ; ninth segment in ♂ produced into a blunt rounded point, slightly more than the basal half covered with minute, colourless spicules ; in the ♀ it is furnished with two lateral processes covered with coarse spicules somewhat as in *Ficalbia mediolineata*, Theo., but not to the same extent.

A species that cannot be confused with any known member of the genus. It is remarkably distinct from *F. elegans* (Taylor) in the adult stage, though it shows some similarity in the larva and pupa. The sexual characteristics exhibited by the larvae are even greater than those of the pupae. The description of the larva is based on a single ♂ skin and two ♀ skins.

Holotype ♂, allotype ♀, 6 ♂♂ and 4 ♀♀ paratypes in the Institute collection.

Genus **Aëdes,** subgenus **Chaetocruiomyia,** Theo.

The members of this subgenus have been looked upon by the writer as species inhabiting more or less dense scrub country, but the discovery of a species at Watten has upset this theory, since Watten is situated in rolling downs country 251 miles by train from Townsville in a south-westerly direction, where growing timber is absent except in isolated patches, for the most part away from water.

The writer has discovered very little concerning the habits of any of the species. The Mt. Molloy species was taken in open forest country in the bed of a dry creek, the nearest pool of water being approximately 100 yards distant ; the Tully species was also taken in similar country in the bed of a creek containing pot-holes of water. In each instance they were captured biting in the late forenoon. They are vicious biters and apparently prefer the region of the head, one specimen being taken in the act of biting the writer's ear. The specimen from Watten was taken while biting in the late afternoon, also on the writer's face. In this instance the only water available was a shallow drain carrying clear very slowly running water from a neighbouring artesian bore. In each of the above instances, prolonged search failed to reveal the presence of further adults, or of the early stages.

In regard to the specimens from Elcho Island there is no doubt that they belong to an undescribed species, and it is to be regretted that the male lacked its abdomen when it came under the care of the writer, since it is apparently the first male of the subgenus to be captured.

There appears to be much in common between this subgenus and the subgenus *Macleaya*, which may at some future date cause the sinking of one within the other.

The types of all the species treated as new in this paper are deposited in the collection of the Institute.

**Chaetocruiomyia wattensis,** sp. n.

♀. *Head* with white flat scales, except for a short narrow lateral patch of dark brown ones on the orbital margin and scattered brownish upright-forked ones; antennae black, basal half of second segment bright yellow, pubescence silvery, verticillate hairs black; palpi with violet black scales, about one-fourth the length of the proboscis, the latter similarly clothed.

*Thorax* with the anterior half of the scutum covered with dense, tawny, narrow scales, posterior half with dense bronzy ones, scutal hairs comparatively long and brown; mid lobe of scutellum with a dense patch of dark brown flat scales, lateral lobes apparently unscaled; prothoracic lobes covered with broad, tawny, lanceolate scales and long brown bristles; pleurae black, densely covered with white flat scales, except the proepimeral sclerite where they are tawny; halteres creamy, knobs with small white flat scales.

*Abdomen* black, segments i to vi inclusive with median white basal patches (those on the second and third segments the largest) and with white lateral basal patches; segments vi to the apex of the venter black-scaled, fifth black with scattered white scales, remaining segments covered with white ones.

*Legs* black, femora with conspicuous white basal rings; fore femora with posterior half mostly white beneath, a conspicuous white subapical ring, tibiae mottled with white scales, first three tarsals with white basal banding, that on the third the narrowest, fourth black, fifth pale brown; mid femora with a median ventral white patch of scales, tibiae with a narrow white-scaled line on the inner side, tarsi similar to those of fore legs; hind femora white at the apex, tibiae mottled with white scales, first four tarsi with white basal banding, that on the fourth the narrowest, fifth all white.

*Wings* with the veins covered with black scales, basal half of costa with the scales very dense, its base with a few white scales; base of the first fork-cell nearer the base of the wing than that of the second fork-cell; stem of the first fork-cell about half the length of its cell, stem of the second fork-cell about the length of its cell.

Length, 3·5 mm.

QUEENSLAND: Watten, x.1927 (*F. H. Taylor*).

Described from a single specimen in perfect condition. It appears to be closest to *C. humeralis*, Edwards, but is easily distinguished by its thoracic and leg ornamentation.

**Chaetocruiomyia tulliae,** sp. n.

♀. *Head* covered with white flat scales in the median area, dark brown ones on the sides, with a few scattered dark upright-forked ones; palpi black-scaled, about one-fourth the length of the proboscis, the latter black; antennae dark brown, pubescence silvery, verticillate hairs black, base of second segment pale.

*Thorax* with the anterior half of scutum covered with snow-white narrow-curved scales, remainder of scutum covered with brown narrow-curved scales (the middle of the scutum is abraded, therefore the extent of the white scaling in this region is unknown, on the sides it extends to the wing-roots), laterally the white scales are broad and lanceolate; scutellum covered with flat brown scales, large ones on the mid and smaller ones on the lateral lobes; pleurae black, covered with white flat scales.

*Abdomen* black, segments i to vi with white basal spots, broad and narrow on segments iii to v inclusive, giving the abdomen to the naked eye the appearance of being banded, segments ii to vi with white lateral basal spots; venter black, apparently with some white scattered scales basally.

*Legs* black, all femora with white basal rings, hind femora with white apices; tibiae black; first and second tarsals of fore legs with white basal banding; first three tarsals of mid legs with white basal banding; first three tarsals of hind legs with white basal banding, fifth wholly white, remaining tarsi of all the legs blackish.

*Wings* with the vein scales black; base of the first fork-cell considerably nearer the base of the wing than that of the second fork-cell; stem of the former about half the length of its cell, stem of the latter about two-thirds the length of its cell; halteres pale, knobs with small white scales.

Length, 3 mm. (*circa*).

QUEENSLAND: Tully, x.1928 (*F. H. Taylor*).

The affinities of this species are difficult to define, but it appears to be nearer to *C. moloiensis*, mihi, than to any of the other species of the subgenus.

**Chaetocruiomyia moloiensis,** sp. n.

♀. *Head* covered with mixed pale and brown flat scales, with a few scattered dark brown upright-forked ones in addition; antennae dark brown, pubescence silvery, verticillate hairs black, second segment with its base yellowish, basal lobe black; palpi and proboscis black-scaled.

*Thorax*: anterior half of scutum covered with snow-white narrow-curved scales, except the humeral angles, posterior half with bronzy-brown narrow-curved scales and two small patches of white ones in front of the scutellum, the latter with some pale broad lanceolate ones on the mid lobe, outer lobes with small brown scales; prothoracic lobes with small brown flat scales and dark brown bristles, scales on lower third of prothoracic lobes white; pleurae black, covered with white flat scales.

*Abdomen* black, segments i to vi with median and lateral white basal spots, the lateral one on the first being entire, joining that of the second segment.

*Legs*: all the femora with a white basal ring, hind femora with a white apical spot; tibiae black; first two tarsals of fore and mid legs with white basal banding, tarsi one to three of hind legs with white basal banding, fifth entirely white, all remaining tarsi black.

*Wings* with the vein scales black, first fork-cell with its base nearer the base of the wing than that of the second fork-cell, stem of the former about half the length of its cell, that of the second fork-cell about the length of the cell; halteres pale, knobs with small white flat scales on their apex.

Length, 3 mm. (*vix*).

QUEENSLAND: Mt. Molloy, iii.1928 (*F. H. Taylor*).

Apparently more closely related to the previous species, *C. tulliae*, than to the other members of the subgenus.

**Chaetocruiomyia elchoensis,** sp. n.

♀. *Head* covered with dark brown flat scales with a small lateral patch below of white flat ones, numerous dark brown upright-forked scales, a small median patch, not reaching the front of the head of white upright-forked ones; antennae dark brown, pubescence silvery, verticillate hairs black, basal two-thirds of second segment yellowish; palpi dusky brown; proboscis brown, labella yellowish.

*Thorax*: anterior half of scutum covered with snow-white narrow-curved scales, except the humeral angles which are bronzy, rest of scutum covered with bronzy narrow-curved scales with four short white-scaled lines reaching from the posterior margin to the level of the wing-roots, in the middle, immediately in front of the scutellum, a small bare oblong area in front of which is a short white line of scales, reaching about its own length beyond the wing-roots; scutellum with white flat scales on the

mid lobe and lanceolate white ones on the lateral lobes ; prothoracic lobes with small bronzy flat scales, except on the lower third where they are white, bristles dark brown ; pleurae dark chocolate-brown with white flat scales (somewhat denuded in appearance).

*Abdomen* dark chocolate-brown, first and penultimate segments without dorsal ornamentation, second segment with a fairly large white median basal spot, segments iii to vi and viii with narrow white basal banding, segments ii to vii with small white basal lateral spots ; venter dark chocolate-brown.

*Legs* dark chocolate-brown, femora with white basal rings, apex of mid and hind femora white ; first and second tarsals of fore legs with white basal banding, remaining tarsi and tibiae not ornamented, mid tarsals missing, hind tibiae dark chocolate-brown ; tarsals 1 to 4 with white basal banding, fifth wholly white.

*Wings* with the vein scales dark chocolate-brown ; first fork-cell about one-third longer than the second, stem of first fork-cell about one-third the length of its cell, that of the second fork-cell about the length of its cell.

♂. Palpi dark chocolate-brown, a little longer than the proboscis, not ornamented, last two segments short, turned down, and somewhat bristly ; thorax and the wings as in the ♀ ; legs as in ♀ ; tarsi of mid legs with the first three segments basally banded white, narrow on the third ; abdomen missing.

Length, 4 mm. (*vix*).

NORTH AUSTRALIA : Elcho Island (*L. E. Cooling*).

Some hesitation is felt in placing this species in *Chaetocruiomyia* as both specimens lack the tuft of very long scales at the extreme base of the wing ; on the other hand the legs and abdomen are typical of the subgenus. It is considered best to place them here in view of the fact that they are not in the best of condition in regard to the wings, which are somewhat abraded ; in addition the pinning leaves much to be desired.

It appears to be related to *C. wattensis*, mihi, on tarsal characters and *C. moloiensis*, mihi, on thoracic ornamentation.

*References.*

LEICESTER, G. F. The Culicidae of Malaya.—Studies from the Institute for Med. Res., F.M.S., iii (3), 1908, p. 18.

MACFIE, J. W. S. & INGRAM, A. The early Stages of West African Mosquitos.—VI.—Bull. Ent. Res., xiii, 1923, p. 409.

Fig. 1. *Ficalbia elegans*, Taylor, ♂, head.

Fig. 2. *Mimomyia metallica*, Leic., ♀, head.

Fig. 3. *M. metallica*, ♂, head.

Fig. 4. *F. elegans*, larva, end of abdomen.

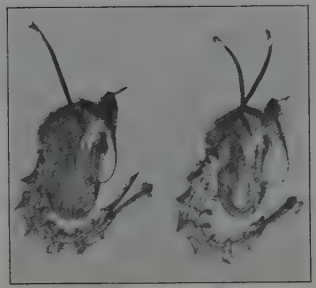


Fig. 5. *M. metallica*, pupal skins.

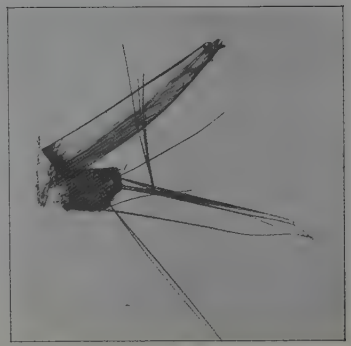


Fig. 6. *M. metallica*, larva, ♀, end of abdomen.

# THE BIONOMICS OF *GLOSSINA MORSITANS* IN THE UMNIATI FLY BELT, SOUTHERN RHODESIA, 1922–23.

By J. K. Chorley.

Contents.


| | | Page |
|---|---|---|
| 1. | Introduction ... ... ... ... ... ... ... ... ... | 279 |
| 2. | Approximate Estimate of the Pupal Period... ... ... ... | 280 |
| 3. | Breeding Season and Period of Greatest Activity ... ... ... | 280 |
| 4. | Parasites... ... ... ... ... ... ... ... ... ... | 283 |
| 5. | Types of Forest utilised by the Fly for Breeding ... ... ... | 288 |
| 6. | Effect of Hot Summer Sun on Exposed Puparia ... ... ... | 290 |
| 7. | Density of Fly and Female Percentage ... ... ... ... | 291 |
| 8. | Movements of Fly Belts ... ... ... ... ... ... | 293 |
| 9. | Summary ... ... ... ... ... ... ... ... ... | 294 |


## 1. Introduction.

The work described in this report was carried out during the dry months, June to November, of 1923, in the Umniati Fly Belt of Southern Rhodesia. At the period under review, this fly belt was about 1,500 square miles in area, its eastern limit lying some fifty miles from the railway line at Gatooma, but to-day, owing to the continued spread eastward, its eastern edge is within twenty miles of that place. A temporary laboratory and camp was built at the confluence of the Umniati and Ongwe rivers, the latter a small tributary of the Umniati, rising to the west on the Mafungabusi Plateau. According to native evidence this locality remained infested with fly after the rinderpest epizootic in 1896. The area is situated below the 3,000 ft. level.

The collection of puparia was confined, except in two or three instances, to a small area of approximately twenty square miles around the junction of the two rivers and on both sides of the Umniati. Within this limited area are found several different types of forest, open mopane bush (a savannah forest consisting chiefly of *Copaifera mopane*), *Brachystegia-Berlinia* forest, heavy river forest, scrub and open grass veldt. Although the area was small in extent, these diverse conditions of forest and woodland offered a unique opportunity for the study of the relationship between the flora and the fly and the seasonal variations that have long been known to occur.

The tables and graphs were compiled from data collected in 1923, but wherever there is any radical divergence from the results obtained during a smaller series of observations made in 1922, the figures are given. Occasional reference is also made to a short visit to the same area during the very wet months of February and March, 1923. On this visit fourteen days were spent in the fly belt. Naturally, some reserve must be placed upon conclusions based upon the small data then collected, but at the same time the whole of the data now available constitutes sufficient evidence upon which a rough outline of the life cycle of the fly, its periods of activity and that of its natural enemies, can be built.

The scope of the work was confined to observations on breeding places, the collection of large quantities of puparia for breeding out parasites, and the making of regular comparable density counts. Owing to the very long larval period of one of the parasites, the work was brought to a close before all the parasites had emerged.

During the three visits paid to this area, over 20,680 apparently live puparia and 37,425 empty cases were collected. In 1923, 18,496 apparently live puparia and 29,684 empty cases were collected. From those retained for experimental

purposes, there emerged 7,440 *Glossina morsitans*, and 2,304 various parasites. The present work has thrown considerable light upon a number of points upon which no data had been previously collected in Southern Rhodesia, in particular upon the breeding season, breeding places, and the degree of parasitism.

## 2. Approximate Estimate of the Pupal Period.

The method employed in calculating the pupal period is not very accurate, and unless laboratory bred puparia exposed to natural conditions are used, this is unavoidable. It is here assumed that in every week's collection of three hundred or more puparia at least one viable puparium had been recently deposited. It is a legitimate assumption to make, for in every week's collection a few partially formed or malformed, unhardened puparia were brought in, indicating that they had been deposited within an hour or so of being collected. The method, however, does give an approximate estimate of the period, which is sufficient to indicate clearly the great difference between the length of the pupal period during the winter and summer months, or to be more precise, the dry cold and dry hot seasons. The maximum period, that is, the period in days calculated from the first day of the week of collection to the date of emergence of the last fly, is used in the table and graph ; the mean period is also given for comparison.

The temperatures given are those registered in the laboratory, an open, well-ventilated pole hut with a grass thatched roof. Readings were taken at 8 a.m. and 1 p.m. Unfortunately a maximum and minimum thermometer was not employed, but it is known that the maximum temperature during October and November rose to a figure higher than was registered at 1 p.m. In fact, over 104° F. was recorded on several occasions during November at about 3 or 4 p.m. Frost was recorded on several occasions during June and July.

It will be noticed (table 1 and fig. 1) that in June the maximum pupal period was seventy days, gradually falling to twenty-one days in November (the absolute minimum would be fifteen days, assuming that the last fly emerged from a puparium deposited on the last day of the week of collection). The mean weekly temperature at 1 p.m. during this period was 79° F. in June, dropping to 76° F. in July, when several heavy frosts were experienced at night, and gradually rising to 97° F. in October and November.

The relative humidity of the air in the laboratory during this same period fell from approximately 80 per cent. to approximately 50 per cent.; thus the rate of evaporation would increase as the dry season became hotter. Without many careful experiments it is not possible to determine which factor caused the reduction in the pupal period, though undoubtedly the temperature factor is the more important, and probably the only one. When breeding out puparia in an incubator in Salisbury it was, however, found necessary to keep the atmosphere inside the incubator fairly humid, and in nature it may be found that a high temperature combined with a low relative humidity may cause increased mortality. Sufficient puparia were not available to follow the question up.

Harris[2] has shown that in Zululand the period of larval development and the pupal period may be twice as long during the winter months as during the summer months. No attempt was made by the author to estimate the length of the larval period in Southern Rhodesia, but the pupal period has been shown to be from three to four times as long in the winter as it is in the summer, *i.e.*, from seventy to twenty-one days. During March, 1923, the pupal period averaged twenty-four days.

## 3. Breeding Season and Period of Greatest Activity.

It appears to be generally accepted by other investigators that the breeding season of *G. morsitans* is at its maximum towards the end of the dry season, that is, just

before the onset of the rains, which in this part of Africa usually commence in November. This applies particularly to Northern Rhodesia and Nyasaland. They consider that during the cold dry months of May and June breeding is continued at a very slow rate. During the wet season the breeding rate is stated to be at its lowest

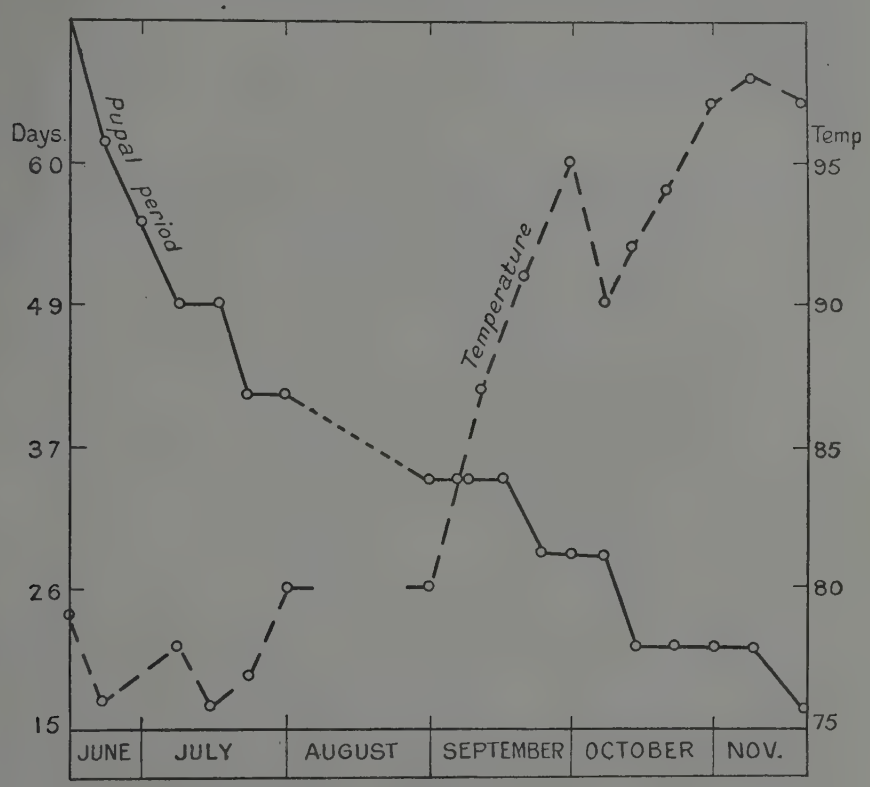



Fig. 1.

point. The following statements have been made by various authorities and are here extracted from their reports :—

Ll. Lloyd.[3] On the high plateau, Congo-Zambezi Watershed. "Searches have resulted in finding 735 living pupae and 1,500 empty cases in 189 positions"—between January and August, 1913. "Only two living pupae taken between December and June in twenty-one searches." "Breeding almost confined to the warmer parts of the dry season."

Ll. Lloyd.[4] "Breeding almost or entirely ceases in the wet season." "Breeding was found to have commenced in the Luangwa Valley about the middle of April."

Lamborn, W. A.[5] "Until April the search for breeding places had been almost without results, five pupae only being found in hard clayey soil. But since then they have been obtained in large numbers as a result of realising that the condition

of the soil is one of the all-important factors in determining whether or not a particular spot will be chosen."

Lamborn, W. A.[6] " Judging by the number of pupae now obtained (October 1915) from captive flies, the breeding season of *G. morsitans* is now in full swing."

Swynnerton, C. F. M.[7] " Breeding was going on both in June and July, and in some quite cold weather, but emergences from the pupae secured only began to take place in numbers with the advent of really warm weather in early September, and continued into November."

More recent work by Lloyd and others in Nigeria tends to show that the wet season, which naturally coincides with the season of long grass and full forest foliage, is a period of food scarcity both for *G. morsitans* and *G. tachinoides*. They suggest that while the grass is long the " fly " has great difficulty in locating game, in that area principally small game, and is forced to feed on both avian and reptilian blood. Nutrition is poor, and consequently the intra-uterine development of the young is retarded. These conclusions are based upon the microscopical examination of the gut contents of thousands of wild flies collected over a period of years.

It is interesting to compare the above results with those obtained by the author during the present investigations.

Working with fifteen native collectors, the following numbers of apparently live puparia were collected during 1923 :—

| | | |
|---|---|---|
| March (2 weeks) ... ... | 656 | (wet season). |
| June (2 weeks) ... ... | 1,951 | (dry season). |
| July ... ... ... ... | 3,469 | |
| August (10 boys) ... ... | 2,756 | |
| September ... ... ... | 4,082 | |
| October ... ... ... | 2,217 | |
| November (2 weeks) ... | 2,575 | |

During August and September, 1922, 412 and 785 whole puparia were collected in each respective month. The figures are not strictly comparable because the boys used in 1922 had to be trained, and the author also had had no previous experience. The boys used in March, 1923, were new and had to be trained, but the gang used from June to November contained several boys trained to the work. Taken generally, about 1,000 apparently live puparia and 1,500—2,000 empty cases were collected each week from June to November (excluding October), and about 500 apparently live puparia and 2,000 empty cases each week during October. Actually the greatest numbers of puparia were collected in September and November. The decrease which occurred in October will be explained later. In March, 1923, only about one-third as many were obtained as were collected later in the year. Allowing for various factors, chiefly the boys' inexperience, the loss of working time due to heavy torrential downpours, and the large area under water, it is considered that breeding was taking place somewhere about the same rate as in July and August. The wet season, 1922–23, was one of the wettest recorded in Southern Rhodesia, the precipitation at Gatooma, the nearest recording station, being 40 inches as compared with a normal of 31 inches.

The male density in March was between 45 and 50, approximately the same as in July, the female percentage, between 11 per cent. and 12 per cent., being a little lower than in July. Clearly, in February and March, during heavy continued rains, a period of maximum forest foliage and long grass, the flies were breeding at a fairly rapid rate, while the female precentage does not indicate any marked degree of hunger.

With regard to the optimum breeding period, there is close agreement between these results and those obtained by Lloyd in Northern Rhodesia, and Lamborn in Nyasaland, who place the period of greatest activity towards the end of the dry season. In the area under observation, from September to November is probably the period of greatest metabolic activity. By September all the winter-deposited puparia have emerged, larviposition is occurring at its maximum rate, and the pupal period is approaching its minimum. The actual density of fly (see table 2) increases gradually from June to September, from which time onwards marked changes occur both in its habitat and density. These changes will be described later.

## 4. Parasites.

From the 18,496 apparently live puparia collected, 2,304 insect parasites were obtained. These consisted of eight or more species. It is regretted that correct identifications have not yet been received for all of these parasites. A full list of those obtained is given below, with the countries from which they have been previously reported.

MUTILLIDAE.

*Mutilla glossinae*, Turn. ... ... N. Rhodesia, Nyasaland.
*Mutilla benefactrix*, Turn. ... ... Nyasaland.

CHALCIDOIDEA.

*Chalcis* (*Brachymeria*) *varipes*, Walk. Gold Coast.
*Stomatoceras exaratum*, Waterst. ... Nyasaland.
*Dirhinus* sp. ... ... ... ... Gold Coast.
*Eupelminus tarsatus*, Wo~~st.~~ ... ... Nyasaland.
*Syntomosphyrum glossinae*, Waterst.... N. Rhodesia, Nyasaland, Uganda.

BOMBYLIIDAE.

*Thyridanthrax* (probably two species) S. Rhodesia, N. Rhodesia, Nyasaland.

Two of these parasites are of considerable economic importance, namely, *Mutilla glossinae* and the Bombyliid. The others are rare or occasional parasites, without, so far as can be ascertained, any economic value.

A fair working knowledge of their life cycle, periods of activity, and general economic value has been gained by collecting large numbers of puparia consistently over a long period, and breeding out the flies and parasites. Two tables have been constructed, one showing the actual number of flies and parasites that emerged each week, which gives an indication of their periods of activity; and the other showing the number of flies and parasites that emerged from each week's collection of puparia, which gives some indication of the date when the puparia were parasitised (see tables 3 & 4, and figs. 2 & 3).

In the tables referred to above, the economic value of each parasite is expressed as a percentage of total emergences (flies and parasites), not as a percentage of total puparia collected. From June to the beginning of September these parasites are practically inactive, but from September onwards a steadily increasing number were bred out, until in November they totalled 84 per cent. of emergences. From November to February no data are available, but in February, 1923, the corresponding figure was 14·2 per cent. This period of intense activity occupies but two to three months of the year; it corresponds, however, with the period of greatest activity of the tsetse fly, and in the area concerned must be a factor of some importance in slowing down the rate of increase of the "fly," and, in consequence, in retarding the spread of the "fly belts."

The percentage of puparia parasitised in each week's collection of puparia is shown in table 4 and fig. 3. This percentage remains fairly steady from June to September and then rises rapidly owing to the number being parasitised by the Bombyliids.

(*a*) *Mutilla glossinae*, Turn.

Although never becoming very numerous, this parasite is one of considerable importance. Between June and the beginning of September it was practically inactive, very few being bred out. From September onwards an increasing number emerged, reaching a maximum of 42 per cent. towards the end of October. The numbers emerging then rapidly decreased to under 5 per cent. in November. It will be noticed from table 4 and fig. 3 that the percentage of puparia collected each week and parasitised by *M. glossinae* remained at about 15 per cent. until September,

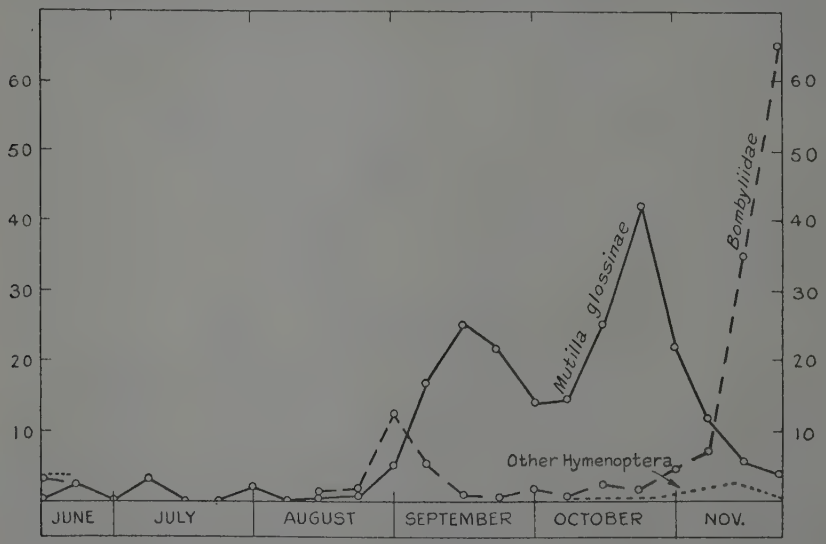



Fig. 2. Relative value and period of activity of the parasites.

when a slight increase occurred followed by a rapid fall. During the dry season of 1922, the activity of *M. glossinae* commenced slightly earlier; in August and September it represented over 56 per cent. of the total emergences, falling to 7·5 per cent. in February, 1923. Puparia collected in November did not produce many Mutillids, indicating that the large number of these parasites that emerged in October had not commenced to oviposit by the middle of November. These figures suggest that there is only one period of intense activity during the year. The cycle is in fact very similar to that of the tsetse fly, the pupal period of the *Mutilla* being very much lengthened during the winter months. It is not clear, however, whether the adults are active and ovipositing during the winter, or whether oviposition occurs at the end of the rains and the parasite overwinters within the puparia. The steady figure of 15 per cent. of parasitised puparia being collected, however, suggests that a certain number of adults are active all the winter.

A point of interest, and also of importance, is the very large proportion of females that occurred. Out of 1,176 Mutillids, 1,000 were females, and this proportion remained approximately the same throughout. No experiments on parthenogenesis were made, though some breeding experiments with mated females were conducted. A number were bred through on Sarcophagid pupae. The pupae were exposed in Salisbury on 29th November, and adults emerged on 5th and 7th February, a period of sixty-seven days. It would be possible to breed a limited number of this parasite for distribution in other "fly areas" if it were found to be absent. As the female is apterous its spread would naturally be slow. The number of young produced by each female is unknown.

(*b*) *Thyridanthrax* sp.

Possibly two species of Bombyliid parasites were bred out during 1922. It is thought that they are both a species of *Thyridanthrax*, and possibly one is *T. abruptus*, Lw., a species obtained in 1914 by Mr. R. W. Jack.

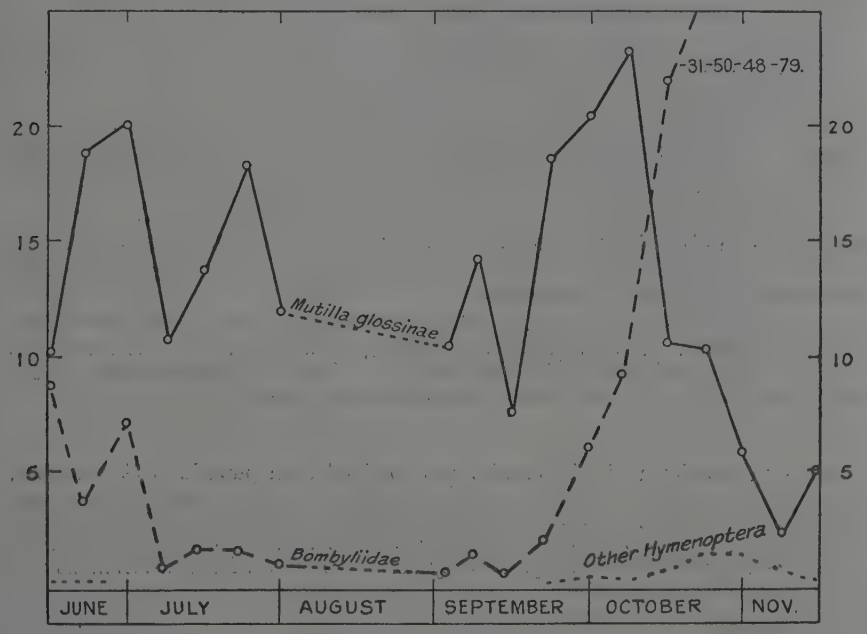



Fig. 3. Percentage of parasites at date of collection.

As in the case of *Mutilla glossinae*, this parasite shows great seasonal activity, culminating in a great wave in November, when it totalled 65 per cent. of emergences. In 1923, 1,084 specimens were obtained. Three fairly distinct waves of activity have been traced, in August, November and March. Puparia collected in June and July gave Bombyliids in August, amounting to 12 per cent. of emergences. The number emerging in September and October was much lower, between 1 per cent. and 4 per cent. of emergences. This fall was followed by another and greater wave at the end of October and beginning of November, the climax of its activity. During February the number of Bombyliids obtained amounted to 6·7 per cent. of emergences.

Puparia collected from October onwards continued to give rise to Bombyliids until May 1924. That is, a certain proportion (probably the greater) emerges as soon as development is complete, the remainder lying dormant in a fully developed larval stage from November to March. It is curious that this period of dormancy should occur during the summer months. The puparia concerned were being kept under observation in Salisbury, some exposed in the laboratory, some in an incubator. Those exposed in the laboratory were collected during the first two weeks in October, the Bombyliids emerging in March; those collected from the middle of October onwards and kept at a constant temperature, slightly warmer than room temperature, gave Bombyliids later, in April and May. A break of one week from 27th April to 3rd May occurred, during which no parasites emerged. It is thought that the humidity conditions were unsuitable, because, on placing a small dish of water in the incubator, emergences recommenced. In the incubator the majority emerged during the night.

Owing to the long pupal period of this parasite, the puparia remaining on 20th May were dissected, and 171 live and fully developed Bombyliid larvae found. These have been counted in the tables as having emerged.

Field work was terminated in 1922 early in October, so that only the first wave of Bombyliids was recorded. In that year they totalled approximately 4 per cent. of emergences and were, in consequence, not considered of importance.

All laboratory breeding experiments on this parasite have failed. When confined in small glass jars, they quickly reduce their wings to stumps and die within twenty-four hours. They have been observed on the veldt hovering over flowers and damp places—darting to and fro with the greatest rapidity.

The percentage of pupae collected each week parasitised by Bombyliids remained low—below 10 per cent. from June to the end of September, gradually increasing from the beginning of October to November, when 79 per cent. of the puparia were parasitised by this insect (see table 4).

The mean pupal period of *M. glossinae* and the Bombyliids, calculated weekly, is shown in table 5. The long pupal period during the winter months is characteristic of both; and puparia collected during 1922 also showed the same tendency on the part of the Bombyliid to aestivate from November to March.

(*c*) *Chalcis* (*Brachymeria*) *varipes*, Walk.

Only one specimen of this parasite was obtained from puparia of *G. morsitans*, this being bred out on 16th August from puparia collected between 24th and 30th June. Other specimens were obtained from Sarcophagid pupae and other flesh-fly maggots, and breeding experiments by Mr. A. Cuthbertson have proved it to be a larval parasite. In all probability the one bred out from *G. morsitans* was an accidental larval parasite.

(*d*) *Dirhinus* sp.

Only one specimen of this parasite was obtained, on 15th July from puparia collected during the last week in June. Several others were afterwards reared from " flesh-fly " pupae exposed on the veldt. Recent work by Mr. A. Cuthbertson has shown it to be a larval parasite of " flesh-fly " maggots.

(*e*) *Eupelminus tarsatus*, Waterst.

This parasite emerged from four puparia. They were all collected between the middle of September and the end of October, the parasites emerging within three weeks of collection. Two males and three or four females emerged from each puparium. Beyond this no further information was obtained. This species has previously been reported from Nyasaland.

(*f*) *Mutilla benefactrix*, Turn.

Only one specimen was obtained, on 23rd October from puparia collected during the first week in October. This species has previously been reported from Nyasaland.

(*g*) *Stomatoceras exaratum*, Waterst.

Five specimens of this parasite were obtained. From puparia collected between 8th and 14th July, one parasite emerged on 1st September, and one between 4th and 10th November, or over four months after collection. From puparia collected between 15th and 21st July, one emerged on 18th November, and another on 22nd December, over five months. The conditions in Salisbury being very different from those in the Umniati Valley, this very long developmental period cannot be taken as normal (they were exposed in Salisbury from 16th November only), yet it does indicate that this parasite can withstand very varying conditions and remain dormant in a larval state over long periods.

(*h*) *Syntomosphyrum glossinae*, Waterst.

In 1922 some seventy cases were found showing the exit hole of a very small parasite; at the time it was suspected that they were caused by *S. glossinae*.

At the time this insect was not known to occur in Southern Rhodesia, but in 1923 thirty-three puparia, or 1·4 per cent. of the total number of parasitised puparia, produced this parasite. Not more than thirty emerged from each puparium, and of these the majority were females. From table 3 and fig. 2, it will be seen that its emergence was distinctly seasonal. Three puparia gave this parasite during June and two more in August. From the middle of September onwards, increasing numbers of puparia parasitised by *Syntomosphyrum* were obtained, twenty-eight in all. It is clear that this parasite is of no great economic importance in Southern Rhodesia, unless it increases in activity between December and February, during which period no observations have been made; but the evidence gained from the examination of thousands of empty cases does not suggest that any such increase takes place.

Some time in June a supply of parasitised "flesh-fly" maggots was obtained from Nyasaland through the courtesy of Dr. Lamborn. These were bred in Salisbury, and more parasitised pupae were sent out to the field station in September. Laboratory breeding was continued at the field station, but no parasites were released until the station was closed down.

At Salisbury further laboratory experiments were carried out designed to prove the suitability of this species as a parasite which could be propagated in a laboratory on a large scale and liberated in fly-infested areas. The very small number bred out from puparia collected on the veldt suggested that it was not an efficient parasite of *G. morsitans*. These experiments, though not as exhaustive as is desirable, explain why *S. glossinae* is able to parasitise so few puparia of *G. morsitans* under natural conditions.

Experiment 1.

Fifty-four experiments were conducted to discover the number of offspring from one fertilised female, the figures being given in table 6. In these experiments one male and one virgin female were enclosed in a tube with one flesh-fly pupa and fed each day by dropping a little sugared water on a slip of blotting paper. The results were extremely uniform, 1–5 males, and 60–134 females being produced by a single female.

A few experiments were made with one female enclosed with two, three, and four pupae, but only one pupa became parasitised. Puparia of *G. morsitans* collected on the veldt never gave more than thirty *Syntomosphyrum*, and it is therefore probable that under natural conditions each female parasitises more than one puparium.

Experiment 2.

Fifteen experiments, conducted with virgin females isolated as they emerged (see table 7), proved that parthenogenesis occurs, males only being produced. This is not entirely an undesirable factor as it ensures that the next generation will be mostly females, having originated from a fertilised parent.

Experiment 3.

Five experiments were conducted to show how far the parasite could burrow into soil in search of buried pupae (see table 8). The results proved that it was unable to penetrate into the lightest soil to a depth of $\frac{1}{8}$ to $\frac{1}{4}$ inch; it is therefore only capable of parasitising pupae just covered with leaves or lying partially exposed on the surface.

Some of the more important factors with regard to this parasite noticed during the course of these experiments are summarised below :—

1. *S. glossinae* is incapable of burrowing more than $\frac{1}{8}$ to $\frac{1}{4}$ inch into light soils.

2. When knocked out of a jar on to the ground exposed to the summer sun (temperature about 110° F.) all are killed immediately. In nature its habitat must be restricted to cool shaded areas, while its ranging powers are necessarily circumscribed.

3. Its power of flight is poor.

4. At temperatures of 55° F., and under, the adult becomes lethargic.

5. Its pupal period is considerably lengthened during the winter months and may cover several months.

6. Its activities are confined mainly to the summer months.

7. During the summer its life cycle is completed within twenty-eight days. There are possibly not more than eight generations in a year.

8. It is very occasionally a hyperparasite of *Mutilla glossinae*, but it is mainly a primary parasite of *G. morsitans*.

9. When parthenogenesis occurs, males only are produced.

10. Fertilised females produce about 80 per cent. females.

11. The maximum number of offspring produced from one fertilised female was 138, 134 females and 4 males.

12. From puparia collected under natural conditions only about twenty-five individuals emerge.

13. It is extremely easy to rear large numbers in the laboratory on "flesh-fly" pupae.

14. The adult female will live over one month, the male slightly less.

Under natural conditions most puparia of *G. morsitans* are discovered well-covered with soil or vegetable débris, and are, in consequence, absolutely safeguarded from attack by *Syntomosphyrum*. It is possible that in countries that do not experience frost or in those that possess a fairly even, warm temperature, *Syntomosphyrum* will continue breeding throughout the year. Under the most favourable conditions of temperature obtainable in Southern Rhodesia, *i.e.*, from September to November, never more than 2 per cent. of collected puparia were parasitised by this insect. It is very doubtful if this figure could be increased by its liberation in "fly" areas.

## 5. Types of Forest utilised by the Fly for Breeding.

Within a radius of five miles of the camp at least six different types of forest or bush existed, namely :—

*a.* Heavy river forest close to the banks of the Umniati River consisting chiefly of evergreens. The dominant species include: *Diospyros mespiliformis*, *Eugenia*

*owariensis, Eugenia cordata, Salix* sp., *Kigelia pinnata, Ficus* sp., *Lonchocarpus capassa, Chrysophyllum argyrophyllum, Phoenix reclinata,* bamboo, etc.

*b.* Mopane forest, in which the dominant species is *Copaifera mopane.* This type covered the greater part of the area.

*c. Combretum-Bauhinia* thickets, locally termed " Ingwaisha."

*d. Brachystegia-Berlinia* forest chiefly on stony, well-drained ground above the mopane.

*e.* Dense thorn thickets—here on deep alluvial soils close to the Umniati and the Ongwe Rivers.

*f.* Low scrub.

*g.* Open vleis.

Practically all types of forest were utilised for breeding, with the exception of the heavy river forest along the Umniati where puparia were never found (see table 9). The open mopane forest was the most heavily infested, and most of the puparia were collected in this type of bush. Pure mopane forest is an open savannah type, clean stemmed, highly deciduous, usually found on a clayey, ill-drained soil. There is little undergrowth, and the grass is short and sweet. Game, particularly impala, is common.

In the Umniati Valley and generally throughout Rhodesia the mopane flushes into leaf soon after the first rains, and retains its leaf until the following August or September. At the edge of wet vleis leaf-fall is not general in August, the trees remaining green and full of leaf throughout the year. These areas may be very restricted, comprising ten to twenty trees close to a dried-up water hole, or may surround a vlei a mile or more in length. Breeding was continuous throughout the mopane forest both in the wet and dry season. The maximum density of fly was reached in September, and the greatest number of puparia were collected in that month. When the leaf-fall became complete, about the first week in October, the density became very considerably reduced, and there was a corresponding drop in the number of puparia collected. During the wet season, the drier portions of this type of forest were heavily infested with fly, and puparia were abundant.

The *Combretum-Bauhinia* thickets were utilised by the fly for breeding until October when the leaf-fall was complete. The grass in these thickets was rank, interspersed with small thorn bush (*Acacia* sp.). After October practically no fly were found in this type of bush, and the search for puparia was discontinued. Isolated thickets of this type occurred in mopane usually on deep soil close to vleis. When they were burnt late in the season, the fires were particularly fierce.

The mixed *Brachystegia-Berlinia* forest, situated on higher, stony, and better drained ground on the west bank of the Umniati, was never heavily infested with fly, nor did the fly become markedly reduced in numbers towards the end of the dry season. Leaf-fall was not general, most of the trees flushing into leaf immediately after the old leaves had fallen. The data collected relating to this area are unfortunately scantier than is desirable. Only a small area was covered with *Brachystegia,* and it is impossible to lay down general rules that would be applicable to large areas of *Brachystegia* such as occurs in the Lomagundi fly-areas. It is not safe to say more than that this particular type of bush was fairly heavily infested and generally utilised by the fly for breeding purposes.

The very dense thorn thickets " Isinanga " and the tangled, overgrown dongas leading down into the river were found to serve as breeding places only during the late dry season, when practically devoid of leaf. During the rains, and until the grass dries out and leaf-fall becomes general, this type of forest is difficult to penetrate. Wart-hog and pig and guinea fowl were present in numbers, while a small herd of buffalo generally lay concealed in the thickets during the day.

Puparia were found in low scrub in very small numbers some distance away from the main mopane bush, while in one instance during August several puparia were found under a fallen log in the middle of a vlei, and at least 100 yards from the edge of the mopane.

Towards the end of the dry season, that is, in October and November, puparia became increasingly more difficult to find in the mopane and *Combretum* thickets—over at least three-quarters of the total area examined.

Finally, it was discovered that the dry bed of the Ongwe River was being extensively used as a breeding ground. The puparia were found buried in the sand and accumulated débris of the river bed, sometimes in large numbers, a hundred or more occurring in an area a few yards square. There was no close overhead shade, although the stream was entirely roofed over with shade trees, often thirty feet or more above the bed of the stream.

The stream ran through mopane bush, scrub and open vleis in which at this time fly was reduced to a minimum or entirely absent. Density counts of fly made along the river bed showed that the fly was just as numerous in November as in open mopane bush in September. The actual density recorded was about 100, but as this figure is practically the maximum that can be caught and counted by one man with one net in an hour, the density may have been greater. Fly was present along the river bed for at least eight miles from the Umniati River, the nearest water. With the advent of the rains many thousands of puparia must perish each year as the river fills up. In most years, however, the surrounding bush would flush into leaf and the fly have spread throughout the bush before the river commenced to run. This would prevent the destruction of an overwhelming proportion of the puparia in the area.

### 6. Effect of the Hot Summer Sun on Exposed Puparia.

It was noticed that the percentage of emergences from each week's collection of puparia diminished as the summer advanced (see table 10). In the winter month of June, 70 per cent. emerged, and this figure diminished regularly each month, until in November only 41 per cent. of puparia produced flies or parasites. In August and September 1922 (a year of veldt fires) the corresponding percentage of emergences was 44·3 per cent., while in February and March, a season of good rains, long grass and thick foliage, 77 per cent. emerged. From these figures it would seem that the wet season, which may be inimical to the adult fly owing to lack of nourishment, is also a season exceptionally favourable to the young which are produced.

A number of experiments were made with batches of fifty to a hundred collected puparia in order to detect whether the direct rays of the sun had any deleterious effect. No corresponding controls were kept, the collections kept in the laboratory being used for this purpose. Four of these groups were exposed uncovered, two covered with half an inch of sand, and two with approximately one inch. The temperature of the ground at the time ranged from 112° F. to 118° F. In every case all the puparia were killed after half an hour's exposure.

A critical examination of hundreds of breeding sites showed that the majority of puparia deposited would be exposed to the direct rays of the sun for some period each day, though most of them would be shaded from the mid-day sun. In explanation of the figures given above, it is thought that the exposure was sufficiently long to kill many of the puparia, and that the decrease in the number of emergences was the direct result of exposure to the sun or contact with the hot ground. It is not known whether the parasites were killed in equal proportion to the tsetse, but, as no parasites emerged from the puparia experimented with, it is probable that they were.

Over the whole period from June to November 16,887 puparia were collected and used for breeding purposes ; of these, 7,134 failed to yield either flies or parasites, so that 58 per cent. emerged. Of this 58 per cent., it has been shown that the number killed by parasites amounted to 23 per cent., leaving approximately 35 per cent. of progeny to continue the race. During the late hot dry season, the number of puparia which failed to yield either flies or parasites was 60 per cent. Of the remaining 40 per cent., 80 per cent. were parasitised, leaving about 8 per cent. of survivors. The figures are, of course, empirical and are only intended to convey a general idea of the amount of destruction occurring, but, when the comparatively slow rate of reproduction of the tsetse fly is remembered, it offers a reasonable explanation of the very slow rate at which *G. morsitans* has spread in Southern Rhodesia.

It is doubtful whether the direct rays of the sun are inimical to the adult flies, for they are frequently seen resting on the hot ground. When making density counts, flies are often observed to rise from the ground on the approach of the collectors and to follow the party, flying close to the ground and settling again when the party stopped, but making no attempt to feed.

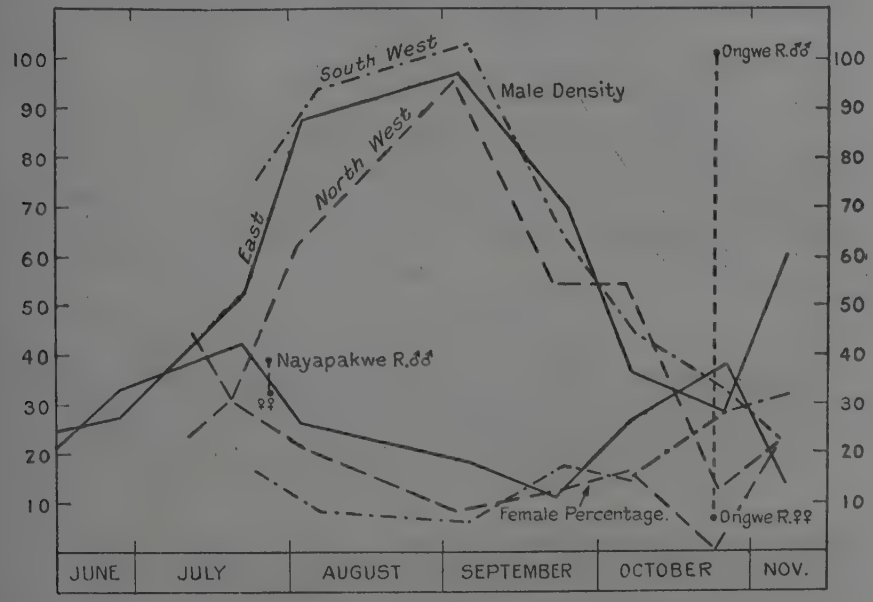



Fig. 4. Male density and female percentage of *G. morsitans*.

## 7. Density of Fly and Female Percentage.

*Male Density.*

As far as possible, accurate density counts were made every fourteen days in the three main belts of mopane, and occasional counts made in other localities as the opportunity occurred. If the weather conditions were unfavourable, the counts were delayed for a day or so. These counts were made by the author, using five

natives as " bait," and have been reduced to the standard usually employed, *i.e.*, collection per net per hour. The results are shown in table 2, and expressed graphically in fig. 4. The density of fly in these belts was approximately the same. In June the density was about twenty, rising gradually to one hundred in September. This has been explained (*loc. cit.*) by the very reduced pupal period and larval period, equivalent to an acceleration in the breeding rate. After September the density began to drop, until in November the density of fly over large areas was reduced to the point of extinction. Certain very small and isolated clumps of mopane, surrounding dried-up pans or termite mounds, remained in full leaf at this period (November). These constitute the so called dry season foci described by numerous

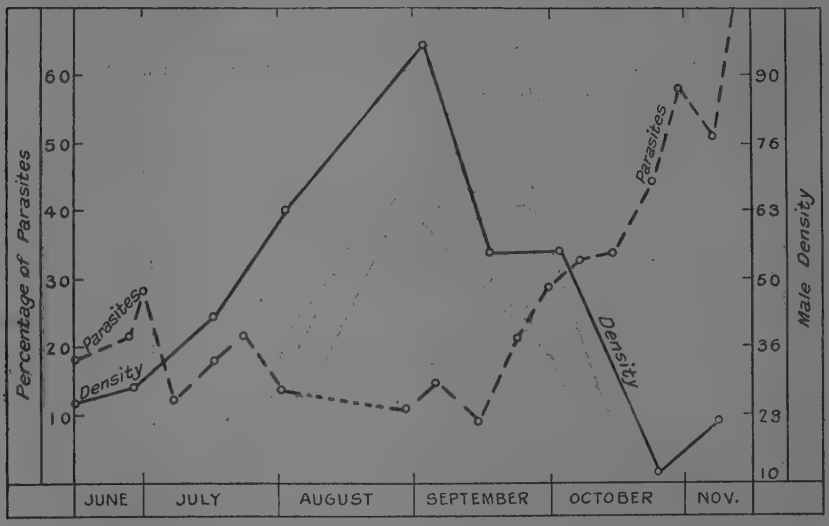



Fig. 5. Correlation of density counts with percentage of parasitism.

observers. In these areas the density was ten to fifteen and actually accounted for all the flies present, the surrounding leafless areas being practically fly-free.

*The Female Percentage.*

The percentage of females captured was on the whole consistently low (table 2 & fig. 4). It was noticed that as the male density increased, the female percentage decreased, whereas the latter rose slightly as the male density decreased. On no occasion did the figures indicate hunger ; it would in fact have been curious if they had done so, because game, particularly kudu, impala and wart-hog, was always plentiful in the area. The female percentage in the belt of mopane nearest camp was always slightly higher than in the other areas. In this belt, big game was rarely seen, though small buck and wart-hog were common.

## 8. Movements of Fly Belts.

This reduction in density in the late dry season has been frequently recorded in Southern Rhodesia. It has been explained as the direct result of leaf-fall, the adult fly forsaking the leafless areas and seeking new areas affording more shade, such as the edge of vleis where the trees may flush into leaf early, water courses, and other similar dry season foci as previously described. This hypothesis was built up upon the known fact that *G. morsitans* is a savannah forest inhabiting fly rarely found in sparsely wooded country, and never in open grass lands unless carried there. The theory postulates a definite migration from one large shadeless area to another very much smaller giving the requisite shade.

The local seasonal migration of the game, that is, the spreading of the game over large areas after the rains have brought on the new grass and filled up the water holes, and the later concentration of the game along water courses after the rains have ceased (usually late in the dry season), has also been held to be contributory to the spread of the fly belts and for this dry season "concentration" around dry season foci. Some species of game, for example eland, wander very long distances during these annual movements, and it is certain that the fly belts do not expand in a similar degree; in fact the spread of the fly belts in Southern Rhodesia has been a very gradual and slow process, though not a very regular one.

When a large herd of game moves out of a thickly infested fly belt into an area free from fly, it is possible, in fact probable, that a few flies accompany it for a few miles. At night the connection is broken, and the following flies in all probability return to their old haunt or die out. It is unlikely that they could establish themselves unless a number of females were present. In Southern Rhodesia experience has shown that there is a certain area, ten miles or more in depth lying on the outside of a definite fly belt, in which occasional fly can be found after an extensive search with the aid of bait cattle. Within this area, cases of nagana occur amongst domestic stock.

In addition to this larger annual migration of the game, there is also a smaller daily movement from their feeding grounds to water. This movement usually occurs in the evening and early morning. Where game is left undisturbed, some species will remain close to water, others move several miles, usually to higher ground, where they lie up during the heat of the day. During the late dry season, this movement is considerably restricted, the game remaining during the day in close proximity to water and green grass. This concentration of game, therefore, synchronises with the general leaf-fall of the deciduous forest, and the observer is at once struck with the apparent intimate connection between game and fly.

Jack[9] from his observations on the Shangani, and Fuller[10] from historical evidence and theoretical deduction, both suggest that, if the game is continually disturbed during this period, the fly will be unable to maintain its hold owing to lack of food supplies and die out. Fuller, in fact, explained the disappearance of fly from the Rustenburg and Waterburg areas in the Northern Transvaal on this basis.

Undoubtedly the connection between game and fly at this period is a very close one, and in those areas where dry season foci are very definite and localised, a possibly effective method of eradicating the fly at once suggests itself, either by catching the flies, game elimination, forest clearing, or by all three methods.

It is difficult to conceive a definite migration of fly from the large areas of leafless mopane in the area under review, to the few dry season foci found in the area. If the density of fly over large areas is 100 in September, then as leaf-fall and migration

(and concentration) of fly takes place, the density of fly in the few small shady foci would naturally increase.

Actually no increase in density was observed. The small local areas of evergreen mopane were always exhausted in fifteen to twenty minutes, in which time ten to fifteen flies were caught. The dry bed of the Ongwe where large quantities of puparia were collected in the late dry season, gave a density of 100, approximately the same as the density recorded in the large mopane belt before leaf-fall took place. This suggests that no appreciable concentration of fly took place. Unfortunately no density counts were made in the river bed before October.

From the data available, it is not possible to say whether more dead puparia were found in the open mopane belts than in the shady river bed, and also it is not possible to say whether the heavy concentrations of puparia found in the river bed were more highly parasitised than puparia found in the open mopane. During the two weeks in November 761 puparia were collected in the open forest, and 1,041 in the river bed. Clearly, as 60 per cent. failed to yield flies or parasites, a certain proportion was being killed in the river bed. It is, however, considered that the majority of dead puparia were collected in the open and that the combined effect of parasitism and the hot summer sun was in this area a contributory cause of the great fall in density that took place throughout the mopane forest at this time.

## 9. Summary.

The pupal period has been shown to be between three and four times as long during the winter months as it is in the summer months.

Breeding continues the whole year round, but the period of greatest density and activity is in September, *i.e.*, towards the end of the dry season. During a period of heavy rains, long grass and full forest foliage, puparia were fairly abundant, while density counts did not indicate any lack of nourishment. The grass in these mopane belts, however, never grows very long.

All types of forest were used for breeding except the heavy river forest. In the mopane a heavy reduction in density occurred after leaf-fall. At the end of the dry season the dry bed of a small well-shaded stream was used extensively as a breeding place. Heavy thorn thickets (Isinanga) and overgrown dongas were only used as breeding places after most of the leaves had fallen.

The puparia are attacked by at least seven species of insect parasites. Of these *Mutilla glossinae* and possibly two species of Bombyliids are the most important. These parasites show definite seasonal activity. At the end of the dry season, 84 per cent. of all emergences were parasites.

The percentage of collected puparia which failed to yield either flies or parasites increased from 23 per cent. in March to 60 per cent. in November. Experiments showed that half an hour's exposure to the sun (118° F.), even when covered with about one inch of sand, was sufficient to kill the puparia.

The combined effect of parasitism and the hot summer sun on deposited puparia is no doubt a contributary cause of the great fall in density that occurs throughout mopane forest at the end of the late dry season after leaf-fall is complete. This statement does not necessarily apply to other areas not examined.

This fly belt has continued to spread and game has increased, although the area has been thrown open to free shooting since 1905. Between 1924 and 1925 the spread eastward has been rapid, and new settlement areas have been endangered.

*References.*

(1) JACK, R. W. Tsetse-fly in Southern Rhodesia, 1918. Bull. Ent. Res., x, 1919, p. 71.

(2) HARRIS, R. H. Tsetse-fly Studies in Zululand. Journal Dept. Agric., Union of South Africa, Sept. 1922.

(3) LLOYD, LL. Bull. Ent. Res., v, 1914, pp. 56, 58, & 60.

(4) LLOYD, LL. Bull. Ent. Res., vii, 1916, p. 67.

(5) LAMBORN, W. A. Second Report on Glossina Investigations in Nyasaland. Bull. Ent. Res., vi, 1915, p. 257.

(6) LAMBORN, W. A. Third Report on Glossina Investigations in Nyasaland. Bull. Ent. Res., vii, 1916, p. 46.

(7) SWYNNERTON, C. F. M. The Tsetse Problem in North Mossurise, Portuguese East Africa. Bull. Ent. Res., xi, 1921, p. 315.

(8) JACK, R. W. Illustrations of Natural Forest in relation to Tsetse Fly. Rhodesia Agric. Journal, April 1914.

(9) JACK, R. W. A Four Years' Experiment in Game Elimination. Rhodesia Agric. Journal, April 1923.

(10) FULLER, C. Tsetse-fly in the Transvaal. Entomology Memoirs, no. 1, Pretoria, 1923.

TABLE I.

*Showing influence of Meteorological Conditions on the duration of the Pupal Period of* G. morsitans. *N.B.—Puparia collected in the field.*

| Date of Collection. | No. Emerged. | Mean Pupal Period. In days. | Maximum Pupal Period. In days. | Mean Temperature For week. 8 a.m. | Mean Temperature For week. 1 p.m. | Mean Relative Humidity at 8 a.m. | Mean Wet Bulb at 8 a.m. |
|---|---|---|---|---|---|---|---|
| June 14–23 ... | 607 | 45·5‡ | 70–77‡ | 53·9 | 79 | 78 | 49·9 |
| ,, 24–30 ... | 464 | 47·8‡ | 63–70‡ | 52·4 | 76 | 76 | 48 |
| July 2–7 ... | 304 | 45·8‡ | 56–63‡ | 48·4† | 77·5 | 81 | 46 |
| ,, 8–14 ... | 579 | 44‡ | 49–56‡ | 49·6† | 77·9 | 76 | 45·9 |
| ,, 15–21 ... | 518 | 37‡ | 49–56‡ | 52·2 | 76 | 70 | 47·6 |
| ,, 22–30 ... | 408 | 31‡ | 42–49‡ | 50 | 77 | 68 | 45 |
| ,, 31–Aug. 4 | 554 | 32‡ | 42–49 | 50·5 | 79·6 | 72 | 45·6 |
| Aug. 26–Sept. 1 | 997 | 26 | 35–42 | 64·5 | 80·5 | 64 | 57·2 |
| Sept. 2–8 ... | 614 | 22 | 35–42 | 63·6 | 84·3 | 76 | 58·7 |
| ,, 9–15 ... | 826 | 20 | 35–42 | 66·1 | 87·1 | 71 | 60 |
| ,, 16–22 ... | 413 | 18·6 | 28–35 | 68 | 91·5 | 64 | 61·5 |
| ,, 23–29 ... | 190 | 18·0 | 28–35 | 75 | 95·5 | 58 | 65 |
| Sept. 30.–Oct. 6 ... | 169 | 18·1 | 28–35 | 66·8* | 90 | 59 | 58·3 |
| Oct. 7–13 ... | 190 | 19 | 21–29 | 71 | 92·7 | 49 | 60·2 |
| ,, 14–20 ... | 138 | 16·6 | 21–28 | 76·3 | 94 | 57 | 66·2 |
| ,, 21–27 ... | 116 | 14·5 | 21–29 | 77·6 | 97·5 | 56 | 66 |
| Oct. 28–Nov. 3 | 223 | 19 | 21–28 | 79 | 97 | 48 | 67 |
| Nov. 4–10 ... | 55 | 11·7 | 14·21 | 80 | 97 | 64 | 71 |

* Cold spell, two days.

† Several heavy frosts.

‡ Shortened owing to being placed in incubator at Salisbury from August 11th to 22nd running at 72–75° F.

TABLE 2.

*Table of densities at different localities.*

| Date. | Time. | Number and Sex. | | | Percentage of Females. | Male Density. | Weather: Remarks. |
|---|---|---|---|---|---|---|---|
| | | MOPANE NORTH WEST. | | | | | |
| 1923. | | | M. | F. | | | |
| July 11 | 3·10 p.m.–4·10 p.m. | 60 | 44 | 16 | 26·6 | 44 | Bright, warm, no wind. |
| ,, 17 | 11·30 a.m.–12·30 p.m. | 47 | 32 | 15 | 31·9 | 32 | Overcast, slight wind. |
| Aug. 2 | 3·30 p.m.–4·30 p.m. | 81 | 63 | 18 | 22·2 | 63 | Bright, warm, still. |
| Sept. 3 | 3·15 p.m.–4·15 p.m. | 106 | 96 | 10 | 9·4 | 96 | Clouds, hot, little wind. |
| ,, 17 | 3·30 p.m.–4·30 p.m. | 65 | 56 | 9 | 13·8 | 56 | Hot, after veldt fire. |
| Oct. 5 | 3·30 p.m.–4·30 p.m. | 69 | 57 | 12 | 17·4 | 57 | Warm. |
| ,, 22 | 3·40 p.m.–4·40 p.m. | 13 | 13 | 0 | 0 | 13 | Hot, bright. |
| Nov. 5 | 4 p.m. –5 p.m. | 28 | 22 | 6 | 21·4 | 22 | Hot. 20 caught close to Ongwe River. |
| | | MOPANE SOUTH WEST. | | | | | |
| July 19 | 12 noon–1 p.m. | 89 | 74 | 15 | 17 | 74 | Bright, warm. |
| Aug. 4 | 11·30 a.m.–12·30 p.m. | 103 | 93 | 10 | 9·7 | 93 | Bright, warm. |
| Sept. 4 | 3·25 p.m.–4·25 p.m. | 112 | 103 | 9 | 8·1 | 103 | Clouds, warm. |
| ,, 18 | 3·30 p.m.–4·30 p.m. | 81 | 66 | 15 | 18·5 | 66 | —— |
| Oct. 7 | 3·30 p.m.–4·30 p.m. | 55 | 46 | 9 | 16·3 | 46 | Hot. |
| ,, 23 | 4 p.m. –5 p.m. | 48 | 34 | 14 | 29·1 | 34 | 30 caught at foci. |
| Nov. 6 | 4 p.m. –5 p.m. | 31 | 21 | 10 | 32·2 | 21 | Hot. 20 caught at foci. |
| | MOPANE EAST OF SIDAGA. | 100 yards from Umniati River close to Camp. | | | | | |
| June 28 | 3·30 p.m.–4·30 p.m. | 42 | 28 | 14 | 33·3 | 28 | Bright, warm. |
| July 18 | 3·30 p.m.–4·30 p.m. | 91 | 52 | 39 | 42·8 | 52 | Bright, warm. |
| Aug. 3 | 3·30–p.m.–4·30 p.m. | 121 | 88 | 33 | 27·3 | 88 | Bright, warm. |
| Sept. 5 | 3·45 p.m.–4·45 p.m. | 121 | 97 | 24 | 19·8 | 97 | Hot, clouds. |
| ,, 19 | 3·30 p.m.–4·30 p.m. | 80 | 70 | 10 | 12·5 | 70 | Hot, dull. |
| Oct. 8 | 3.45 p.m.–4.45 p.m. | 51 | 37 | 14 | 27·4 | 37 | Hot, bright. |
| ,, 24 | 4 p.m. –5 p.m. | 47 | 29 | 18 | 38·3 | 29 | Hot, clear. |
| Nov. 7 | 4·30 p.m.–5·30 p.m. | 70 | 60 | 10 | 14·2 | 60 | Hot, clear. |
| | | GUSU AND INGWAISHA. | | | | | |
| July 20 | 12 noon –1 p.m. | 48 | 38 | 10 | 20·8 | 38 | Exhausted in one-eighth hour — Gusu. |
| ,, 21 | 12 noon –1 p.m. | 72 | 65 | 7 | 9·7 | 65 | Warm. Salt Lick. |
| Sept. 20 | 3·30 p.m.–4·30 p.m. | 65 | 63 | 2 | 3 | 63 | Hot, dull. |
| Oct. 9 | 3·35 p.m.–4·35 p.m. | 10 | 10 | 0 | 0 | 10 | Hot, bright. |
| | | MOPANE AT NGATSURU. | | | | | |
| June 9 | 3·30 p.m.–4·30 p.m. | 32 | 25 | 7 | 21·8 | 25 | Warm, bright. |
| | | MOPANE AT NYARAPAKWE. | | | | | |
| July 25 | 3·30 p.m.–4·30 p.m. | 58 | 39 | 19 | 32·7 | 39 | Warm, bright. |
| | | BED OF ONGWE RIVER. | | | | | |
| Oct. 25 | 4 p.m.–5 p.m. | 109 | 101 | 8 | 7·3 | 101 | Hot, bright. |

TABLE 3.

*Showing the Weekly Percentage of Parasitism.*

*The figures shown are the actual numbers of Tsetse and Parasites which emerged each week in the Laboratory.*

| Date. | *G. morsitans.* | | | Total Parasites. | *Mutilla glossinae.* | | | Bombyliid. | *S. glossinae.* | Others. | Total Percentage of Parasitism. | By *Mutilla glossinae.* | By Bombyliid. | By other Hymenoptera. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | M. | F. | | | M. | F. | | | | | | | |
| June 14–23 ... | 34 | 18 | 16 | 2 | 0 | — | — | 0 | 2 | 0 | 5·5 | 0 | — | 5·5 |
| ,, 24–30 ... | 40 | 23 | 17 | 2 | 1 | — | 1 | 0 | 1 | 0 | 4·7 | 2·3 | 0 | 2·3 |
| July 1–7 ... | 65 | 25 | 40 | 0 | 0 | — | — | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ,, 8–14 ... | 85 | 44 | 41 | 3 | 3 | 2 | 1 | 0 | 0 | 0 | 3·5 | 3·5 | 0 | 0 |
| ,, 15–21 ... | 150 | 62 | 88 | 1 | 0 | — | — | 0 | 0 | 1*a* | ·6 | 0 | 0 | ·6 |
| ,, 22–28 ... | 195 | 82 | 113 | 0 | 0 | — | — | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ,, 29–Aug. 4 | 177 | 91 | 86 | 4 | 4 | 2 | 2 | 0 | 0 | 0 | 2·2 | 2·2 | 0 | 0 |
| Aug. 5–11 ... | 427 | 208 | 219 | 0 | 0 | — | — | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ,, 12–18 ... | 558 | 238 | 320 | 7 | 2 | — | 2 | 3 | 1 | 1*b* | 1·2 | ·3 | ·5 | ·3 |
| ,, 19–25 ... | 925 | 432 | 493 | 21 | 8 | 3 | 5 | 12 | 1 | 0 | 2·2 | ·8 | 1·3 | ·1 |
| ,, 26–Sept. 1 | 632 | 315 | 317 | 131 | 38 | 12 | 26 | 92 | 0 | 1*d* | 17·2 | 5 | 12 | ·1 |
| Sept. 2–8 ... | 364 | 208 | 156 | 116 | 84 | 37 | 47 | 32 | 0 | 0 | 24·3 | 17·5 | 6·8 | 0 |
| ,, 9–15 ... | 423 | 204 | 219 | 149 | 140 | 28 | 112 | 9 | 0 | 0 | 26 | 24·4 | 1·5 | 0 |
| ,, 16–22 ... | 794 | 382 | 412 | 230 | 218 | 24 | 194 | 10 | 2 | 0 | 22·4 | 21·2 | ·9 | ·2 |
| ,, 23–29 ... | 777 | 397 | 380 | 157 | 132 | 20 | 112 | 20 | 5 | 0 | 16·8 | 14·1 | 2·1 | ·5 |
| ,, 30–Oct. 6 | 533 | 268 | 265 | 105 | 94 | 12 | 82 | 9 | 1 | 1*d* | 16·4 | 14·7 | 1·4 | ·3 |
| Oct. 7–13 ... | 348 | 194 | 154 | 150 | 131 | 10 | 121 | 15 | 3 | 1*c* | 30 | 26·3 | 3 | ·7 |
| ,, 14–20 ... | 184 | 88 | 96 | 160 | 147 | 16 | 131 | 10 | 3 | 0 | 46·5 | 42·7 | 2·9 | ·9 |
| ,, 21–27 ... | 192 | 94 | 98 | 79 | 60 | 4 | 56 | 13 | 5 | 1*e* | 29·1 | 22·1 | 4·8 | 2·2 |
| ,, 21–Nov. 3 | 228 | 121 | 107 | 67 | 36 | 3 | 33 | 24 | 7 | 0 | 22·7 | 12·2 | 8·1 | 2·4 |
| Nov. 4–10 ... | 177 | 79 | 98 | 143 | 23 | 1 | 22 | 114 | 2 | { 3*c* 1*d* } | 44·6 | 7·2 | 35·6 | 1·8 |
| ,, 11–18 ... | 83 | 39 | 44 | 202 | 18 | 1 | 17 | 183 | 0 | 1*d* | 70 | 6·3 | 64·2 | ·3 |
| ,, 19–25 ... | 49 | 28 | 21 | 54 | 12 | 1 | 11 | 42 | 0 | 0 | 52·4 | 11·6 | 40·7 | 0 |

*a Dirhinus* sp.? *b Chalcis* sp.? *c Eupelminus tarsatus.* *d Stomatoceras exaratum.*
*e Mutilla benefactrix.*

TABLE 4.

*Table showing the Percentage of Parasitism at the Date of Collection.*

| Date of Collection. | No. of *G. morsitans.* | Total Parasites. | Mutillid. | Bombyliid. | Chalcids. | Total Percentage of Parasitism. | By Mutillid. | By Bombyliid. | By Chalcids. |
|---|---|---|---|---|---|---|---|---|---|
| June 9 ... | 25 | 1 | 0 | 1 | 0 | 3·4 | 0 | 3·4 | 0 |
| ,, 14–23 | 597 | 147 | 78 | 66 | 3 Syn. | 19·6 | 10·4 | 8·8 | ·4 |
| ,, 24–30 | 464 | 144 | 117 | 24 | 3 { 1 Syn. 1 Dirhinus. 1 Chalcis. } | 23·6 | 19·2 | 3·9 | ·5 |
| July 2–7 ... | 304 | 114 | 84 | 30 | 0 | 27·2 | 20·1 | 7·1 | 0 |
| ,, 8–14 | 579 | 86 | 74 | 10 | 2 Stom. | 12·9 | 11·1 | 1·5 | ·3 |
| ,, 15–21 | 518 | 105 | 86 | 16 | 3 { 1 Syn. 2 Stom. } | 16·7 | 13·8 | 2·4 | ·5 |
| ,, 22 ... | 93 | 25 | 22 | 3 | 0 | 21·1 | 18·6 | 2·5 | 0 |
| ,, 22–24 | | | | | | | | | |
| Nyarapakwe | 315 | 18 | 18 | 0 | 0 | 5·4 | 5·4 | 0 | 0 |
| July 31–Aug. 4 | 554 | 92 | 83 | 9 | 0 | 14·0 | 12·6 | 1·3 | 0 |
| Aug. 21–Sept. 6 | 997 | 128 | 116 | 12 | 0 | 11·3 | 10·3 | ·9 | 0 |
| Sept. 2–8 ... | 614 | 116 | 106 | 8 | 2 Syn. | 15·9 | 14·5 | 1·1 | ·3 |
| ,, 9–15... | 826 | 78 | 69 | 7 | 2 Syn. | 8·6 | 7·6 | ·7 | ·2 |
| ,, 16–22... | 413 | 119 | 100 | 13 | 6 { 5 Syn. 1 Eup. } | 22·3 | 18·8 | 2·4 | 1 |
| ,, 23–29... | 190 | 71 | 54 | 15 | 2 { 1 Syn. 1 Stom. } | 27·2 | 20·6 | 5·7 | ·9 |
| ,, 30–Oct. 6 | 169 | 85 | 60 | 23 | 2 Syn. | 33·4 | 23·6 | 9 | ·8 |
| Oct. 7–13... | 190 | 96 | 30 | 64 | 2 { 1 Syn. 1 Eup. } | 34 | 10·4 | 22·4 | ·7 |
| ,, 14–20... | 138 | 109 | 25 | 78 | 6 { 4 Syn. 2 Eup. } | 44·1 | 10·1 | 31·6 | 2 |
| ,, 21–27... | 116 | 166 | 18 | 142 | 6 Syn. | 58·8 | 6·3 | 50·4 | 2·1 |
| ,, 28–Nov. 3 | 283 | 297 | 17 | 276 | 4 Syn. | 51·2 | 3 | 47·6 | ·6 |
| Nov. 4–10 ... | 55 | 307 | 19 | 287 | 1 Syn. | 84·8 | 5·2 | 79·2 | ·4 |

TABLE 5.

| Date of Collection. | *Mutilla glossinae.* | Bombyliid. |
|---|---|---|
| | In days. | In days. |
| June 14–23 ... | 80 | 78 |
| ,, 24–30 ... | 78 | 66 |
| July 1–7 ... ... | 71 | 61 |
| ,, 8–14 ... | 75 | 51 |
| ,, 15–21 ... | 60 | 42 |
| ,, 22 ... ... | 48 | 43 |
| ,, 24–25 ... | 53 | — |
| ,, 29–Aug. 4 ... | 47 | 32 |
| Aug. 26–Sept. 1 ... | 38 | 26 |
| Sept. 2–8 ... | 34 | 27 |
| ,, 9–15 ... | 27 | 24 |
| ,, 16–22 ... | 21 | 10 |
| ,, 23–29 ... | 17 | 27 and 162 |
| ,, 30–Oct. 6 ... | 15 | 22 ,, 161 |
| Oct. 7–13 ... | 12 | 16 ,, 153 |
| ,, 14–20 ... | 15 | 15 ,, 200* |
| ,, 21–27 ... | 18 | 16 ,, 190* |
| ,, 28–Nov. 3 ... | 22 | 13 ,, 200* |
| Nov. 4–10 ... | 19 | 9 ,, 200* |

Mean pupal period in days of *M. glossinae* and the Bombyliid.

* Dissected individuals, see p. 286.

TABLE 6.

*Breeding* Syntomosphyrum glossinae *in Laboratory.*

| Date of Exposure. | Emergences. | | Date of Emergence. | Date of Exposure. | Emergences. | | Date of Emergence. |
|---|---|---|---|---|---|---|---|
| | *M.* | *F.* | | | *M.* | *F.* | |
| Nov. 28, 1923 | 5 | 85 | Jan. 2, 1924 | Feb. 7, 1924 | 4 | 72 | Mar. 11, 1924 |
| ,, | 1 | 80 | ,, | ,, | 3 | 62 | ,, |
| ,, | 5 | 35 | Jan. 4, 1924 | ,, | 2 | 75 | ,, |
| ,, | * | 45 | ,, | ,, | 3 | 73 | Mar. 12, 1924 |
| Jan. 10, 1924 | 3 | 58 | Feb. 5, 1924 | ,, | 6 | 80 | ,, |
| ,, | 4 | 85 | ,, | ,, | 2 | 82 | ,, |
| ,, | 2* | 79 | ,, | ,, | 2 | 97 | ,, |
| ,, | 4 | 67 | ,, | ,, | 3 | 109 | ,, |
| ,, | 4 | 89 | ,, | ,, | 3 | 83 | ,, |
| ,, | 5 | 93 | ,, | ,, | 3 | 90 | ,, |
| ,, | 2 | 56 | Feb. 6, 1924 | ,, | 1 | 86 | ,, |
| ,, | 2 | 62 | ,, | ,, | 3 | 86 | ,, |
| ,, | 4 | 134 | ,, | ,, | 2 | 70 | ,, |
| ,, | 8 | 114 | ,, | ,, | 4 | 70 | ,, |
| ,, | 6 | 121 | ,, | ,, | 1* | 57 | ,, |
| ,, | 25 | 76 | ,, | ,, | 3 | 84 | ,, |
| ,, | 3 | 81 | ,, | ,, | 4 | 73 | ,, |
| ,, | 5 | 91 | ,, | ,, | 4 | 89 | ,, |
| ,, | 7 | 131 | ,, | ,, | 5 | 77 | ,, |
| ,, | 4 | 67 | Feb. 8, 1924 | ,, | 4 | 76 | ,, |
| ,, | 3 | 86 | ,, | ,, | 3 | 66 | ,, |
| Feb. 7, 1924 | 2* | 51 | Mar. 10, 1924 | ,, | 2 | 61 | ,, |
| ,, | 3* | 66 | ,, | ,, | 1* | 36 | Mar. 13, 1924 |
| ,, | 3* | 82 | ,, | ,, | 4 | 68 | ,, |
| ,, | 3 | 60 | Mar. 11, 1924 | ,, | 3 | 53 | ,, |
| ,, | 2 | 65 | ,, | | | | |

* A few pupae failed to produce adults, and the sex was undetermined.

TABLE 7.

*Females taken as emerging from puparia. Parthenogenesis of* Syntomosphyrum glossinae.

| Experiment No. | Date of Exposure. | Date of Emergence. | Number and Sex. |
|---|---|---|---|
| 1 | Feb. 7, 1924 | Mar. 13, 1924 | 76 males |
| 2 | ,, | ,, | 92 ,, |
| 3 | ,, | ,, | 91 ,, |
| 4 | ,, | ,, | 67 ,, |
| 5 | ,, | ,, | 73 ,, |
| 6 | Jan. 10, 1924 | Feb. 7, 1924 | 80 ,, |
| 7 | ,, | ,, | 70 ,, |
| 8 | Feb. 7, 1924 | Mar. 13, 1924 | 65* ,, |
| 9 | ,, | ,, | 80 ,, |
| 10 | ,, | ,, | 59* ,, |
| 11 | ,, | ,, | 50* ,, |
| 12 | ,, | ,, | 90 ,, |
| 13 | ,, | Mar. 14, 1924 | 52* ,, |
| 14 | ,, | ,, | 93* ,, |
| 15 | ,, | ,, | 70 ,, |

* A few pupae failed to produce adults, and the sex was undetermined.

TABLE 8.

*Showing the inability of* S. glossinae *to burrow into the soil.*

| Date. | Exposed. | How covered. | Pupae Parasitised. |
|---|---|---|---|
| Nov. 29, 1923 | 50 Pupae | Buried ½ inch | Nil. |
| Dec. 20, 1923 | ,, | ,, ½ ,, | ,, |
| Feb. 7, 1924 | ,, | Just covered | ,, |
| ,, 25, 1924 | ,, | ,, ,, | ,, |
| ,, 26, 1924 | ,, | Light sand | One parasitised, probably exposed. |

TABLE 9.

*Showing number of puparia collected in different localities and different types of forest.*

| Date of Collection. | Mopane S.W. | | Mopane N.W. | | Mopane East of River. | | Gusu. | | Ingwaisha. | | Isinanga. | | River Bed. | | Nyara-pakwe. | | Total for Month. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | A. | E. | A. | E. | A. | E. | A. | E. | A. | E. | A. | E. | A. | E. | A. | E. | A. | E. |
| June 14–30 ... | 628 | 1,274 | 282 | 552 | 742 | 2,375 | 72 | 146 | 283 | 808 | 2 | 15 | — | — | — | — | 2,009 | 5,170 |
| July ... ... | 1,449 | 1,498 | 836 | 1,009 | 1,609 | 3,244 | 333 | 813 | 118 | 120 | 6 | 180 | — | — | 446 | 622 | 4,797 | 7,486 |
| Aug. 1–4, 27–31 | 474 | 148 | 321 | 206 | 769 | 656 | 380 | 290 | 274 | 124 | — | — | — | — | — | — | 2,218 | 1,424 |
| September ... | 450 | 326 | 838 | 1,303 | 2,043 | 3,781 | 198 | 150 | 210 | 250 | 398 | 554 | — | — | — | — | 4,137 | 6,364 |
| October ... | 65 | 185 | 546 | 1,169 | 1,409 | 3,497 | — | — | 26 | 100 | 138 | 390 | 1,512 | 1,851 | — | — | 3,696 | 7,192 |
| November 1–10 | — | — | 168 | 300 | 279 | 343 | 314 | 240 | — | — | — | — | 1,041 | 1,173 | — | — | 1,802 | 2,056 |
| Totals ... | 3,066 | 3,431 | 2,991 | 4,539 | 6,851 | 13,896 | 1,297 | 1,639 | 911 | 1,402 | 544 | 1,139 | 2,553 | 3,024 | 446 | 622 | 18,659 | 29,692 |

A.=Living puparia. E.=Emerged puparia.

TABLE 10.

*Showing the Percentage of Puparia that emerged each month.*

| Month of Collection. | Total Emergences (Parasites and Tsetse). | No. Dissected. | Percentage of Emergences. |
|---|---|---|---|
| June 14–30 ... ... | 1,378 | 573 | 70 |
| July ... ... ... ... | 2,158 | 1,311 | 62 |
| August 1–4, 27–31 ... | 1,771 | 985 | 64 |
| September ... ... ... | 2,427 | 1,655 | 59 |
| October ... ... ... | 1,108 | 1,109 | 50 |
| November 1–10 ... ... | 1,074 | 1,501 | 41 |
| March ... ... ... | 504 | 152 | 77 |

N.B.—Where live Bombyliid larvae were found on dissection they were counted as having emerged.

# MOSQUITOS FROM THE SOLOMON ISLANDS.

By R. W. Paine,
*Entomologist, Suva, Fiji,*
and
F. W. Edwards,
*British Museum, Natural History.*

(Plates XIII & XIV.)

## 1. *Introductory.*

(R. W. Paine.)

During the course of work on coconut pests in the British Solomon Islands Protectorate, from August to October, 1928, I took the opportunity to make a collection of mosquitos. Ten weeks were spent in the country, but most of this time was occupied in travelling round the group on brief visits to many islands, and on only two occasions were more than three days spent in any one locality. It was not possible, therefore, to make anything like an exhaustive collection of the mosquito fauna.

With the exception of one heavy rainstorm on Guadalcanar, lasting two days, the weather during the period of my visit was rather dry, and there was a surprising lack of temporary surface pools and water in tree-holes, for a country where the rainfall is for the most part more than 100 inches. It seems likely that at least a dozen more species would occur commonly during periods of heavier precipitation.

It was noticeable that certain species appeared to be more abundant in some islands than in others. *Rachionotomyia solomonis* was not met with except in the Russel Group of islands, where it was very common in coconut husks, although numerous husks were examined on Guadalcanar and Malaita. *Aëdes variegatus*, surprisingly rare on the two last-named islands, was very generally found in the most "open" coconut husks in the Russel Group. *Aëdes imprimens*, one of the commonest and most obnoxious mosquitos on Guadalcanar, was never seen in the western part of the group.

The mosquito fauna appeared to get richer to the westward—as one would expect, and it was unfortunate that only one day could be spent at Faisi, where numerous breeding-places were noted in a short walk through the forest bordering a coconut plantation. As this island was visited only two days before leaving the group, no attempt was made to collect larvae, as adults could not have been reared.

The majority of the collections were made in houses and coconut plantations. On only five occasions were excursions made into the forest areas—twice on Guadalcanar, once on Malaita, once at Cape Marsh, and once at Faisi.

No attempt was made to obtain statistical data on the occurrence or non-occurrence of certain species in certain types of breeding-places. The collection was merely the result of an investigation of as many different types of breeding-places as were met with during the course of other work on coconut plantations.

It must strike anyone visiting the group how inadequate is the screening of the average planter's house. In only two of the houses visited were the bathrooms properly screened, and judging by the abundance of *Anopheles* mosquitos in those bathrooms which I happened to use, stricter attention to screening would seem to be very desirable and necessary in antimalarial work.

One cannot blame residents of the country for neglecting to take all the precautions against malaria that a visitor would endeavour to take, but it seems quite

certain that, with a more rigorous house inspection and a more adequate type of house screening, the fever incidence could be very materially reduced and discomfort from continual mosquito bites indoors completely avoided.

### 2. *Annotated List of Species observed.*

(R. W. Paine.)

Twenty-three species were met with in all, these including 16 of the 22 previously found in the Solomons by Carment and others. The six species and varieties already recorded which I did not find were *Rachionotomyia distigma*, Edw., *R. quasiornata*, Taylor, *Aëdes edwardsi*, Barr. var. *tulagiensis*, Edw., *A. variegatus*, Dol. var. *tongae*, Edw., *A. amesi*, Ludlow, and *Taeniorhynchus uniformis*, Theo.

**Anopheles punctulatus,** Dön.

Adults were extremely abundant in houses visited along the coast of Guadalcanar, and many had found their way inside the screening. I caught 12 in the space of as many minutes in a bathroom (not screened) at Tenaru one morning at 6.30 a.m. Larvae were not seen anywhere near this house, although a thorough search was made in all the water in the immediate neighbourhood. A crab-hole was dug out, but it was quite 6 ft. down to the water-line, and by the time this was reached the water was so full of mud and soil that it would have been impossible to detect the presence of mosquito larvae, had such been there.

I was bitten on only two occasions to my certain knowledge during my stay of ten weeks, and did not contract malaria; but it was necessary to use a mosquito net at night, and in the evening mosquito boots were worn.

The early stages of *A. punctulatus* were found for the most part in very small areas of water of a purely temporary nature, such as that found after rain in hoof-marks or other shallow ground cavities of limited extent. Several larger pools were searched for larvae—notably that at Banika shown in the photograph (Pl. xiii, fig. 1)—but in such places very few or none were found, perhaps owing to the presence of predators. The larvae were found in suitable localities both in bright sunlight and in the shade, frequently associated with *Culex annulirostris*. Typical breeding-places are those on Kulambangra shown in the photographs (Pl. xiii, fig. 2, and Pl. xiv, fig. 1).

The pool at Banika was of some 20 ft. extent, several feet deep for the most part, and matted with water-weed on the surface. Although near tide-mark, it was fed by a spring at one end and was quite permanent, but swollen at times by rain. Numerous *Notonecta*, *Gerris* and Odonate larvae were present. Although repeated search was made, very few mosquitos were found, and *Anopheles* only on one occasion, when the pool was rather full after heavy rain.

**Uranotaenia quadrimaculata,** sp. n.

Larvae and pupae were found in a coconut husk at Rere, Guadalcanar, 19.viii; in a coconut husk on Malaupaina, 4.ix; and in leaf-axils of taro growing wild beside a path in the forest, 26.viii. In the first instance the *Uranotaenia* was accompanied by *Aëdes albolineatus* and *A. variegatus*; in the other two localities there were no associated species.

**Uranotaenia albescens,** Taylor (?).

A damaged specimen, probably of this species, was taken in the net in deep shade beneath a mango tree at Banika, in September.

**Uranotaenia argyrotarsis,** Leic.

Pupae were found in a small rot-hole at the base of a large tree in forest behind Tenaru plantation, Guadalcanar, 27.viii. The water was very foul and much contaminated with decayed leaves. One male was reared.

**Rachionotomyia solomonis,** Edw.

Larvae and pupae were found in coconut husks at Ufa, 20.ix, in company with *Aëdes variegatus*, and at Fai-ami, 27.ix, with *Armigeres malayi* and *Aëdes albolineatus*.

**Rachionotomyia filipes,** Walk.

Larvae and pupae were found on one occasion only, in water in leaf-axils of a large wild Aroid and in leaves on the ground in forest at Ilu, Guadalcanar, 26.viii. The larvae were predacious and attacked each other in captivity; four females were reared from the material collected. No other larvae were found associated, although larvae of *Uranotaenia quadrimaculata* were found in axillary water of another species of Aroid (the cultivated taro) within a few yards.

Several females were captured at Roviana, New Georgia, in June 1929 by a nursing sister and forwarded by Mr. E. G. Sayers through Dr. P. A. Buxton.

**Pardomyia aurantia,** Theo., var.

Larvae were found associated with and feeding upon *Culex hilli*, *Aëdes funereus* and *Anopheles punctulatus* in a muddy ditch with some algal scum and water in hoof-marks on Lady Lever plantation, Kulambangra, 3.x (Plate xiv, fig. 1). Several females of the *Pardomyia* were reared.

**Armigeres malayi** var. **breinli,** Taylor.

This is widely distributed in the islands and bites by day in the forest areas, and less frequently in the plantations. It seemed at the time of my visit to be commoner in the west than in the east of the group. It was the dominant species in the semi-mangrove-swamp scrub at Kaylan (Russel Group), where it bit fiercely. Larvae were only found once—in a coconut husk at Fai-ami (Russel Group), associated with *Rachionotomyia solomonis*. The larvae have, in addition to the more usual method of locomotion, an eel-like movement whereby they are able rapidly to burrow into the semi-liquid filth on which they appear to feed.

**Aëdes (Stegomyia) argenteus,** Poiret.

Universally met with in the plantation homesteads. The early stages were seen in nearly every case in water drawn from tanks inadequately screened. These mosquitos were therefore emerging from time to time from water used in flower vases, ant traps, etc., and contributed in no small way to indoor discomfort.

**Aëdes (Stegomyia) variegatus,** Dol.

In Cape Marsh (Russel Group), and probably also in the more westerly islands—though this was not specially noted—this species was abundant, its early stages being found in almost every coconut husk containing water. In the eastern part of the group it was not commonly met with, its place being taken to a large extent by *A. albolineatus* and *A. albilabris*.

Whereas in Fiji *A. variegatus* var. *pseudoscutellaris* is a very common and most obnoxious day feeder, making itself felt to an unpleasant degree on almost every island both in plantation and forest areas, the form occurring in the Eastern Solomons (typical *variegatus*) is not troublesome. During five weeks spent almost entirely out in the plantations I was only bitten on one occasion.

Apart from the numerous occasions on which the species was found breeding in coconut husks, larvae of *A. variegatus* were found in a tree-hole at Tenaru in company with several other species, and in an old tin at Su'u, Malaita, in company with *Aëdes albolineatus*.

**Aëdes (Stegomyia) albolineatus,** Theo.

This species was very commonly found in coconut husks and small tree-holes in the eastern part of the group. With the exception of those reared in captivity and a few seen flying about at the entrance to a breeding-place, no adults were seen, and so far as I am aware I was never bitten by this species. The breeding-places were similar to those of *A. variegatus*, and it seemed largely to replace this species on the eastern islands, though the two were found in association on more than one occasion. I have only one record of this species from the Russel Group (Cape Marsh), but my search for it was very inadequate. Its occurrence in a barrel used to catch rain-water from roof-guttering on Ysabel was unexpected, in view of its habitat in other localities. The following definite records were noted :—

In hole in tree (*Inocarpus edulis*) at edge of forest behind Tenaru plantation, Guadalcanar, 27.viii; associated with *A. variegatus*, *A. albilabris*, *Culex fraudatrix* var. *solomonis*, and probably a *Rachionotomyia* (adult seen in tree-hole but no early stages found).

Axils of leaves of Sago palm : Ysabel.

Coconut husk : Su'u, 8.ix, with *A. variegatus*.

Old tin : Su'u, Malaita, 21.viii, with *A. variegatus*.

Tree-hole : Manaba plantation, Malaita, 10.ix, with *A. albilabris*.

In barrel collecting rain-water from guttering of house, half covered in at the top : Fulakoro, Ysabel, 11.x, alone.

Coconut husk : Fai-ami, 27.ix, with *Armigeres breinli* and *Rachionotomyia solomonis*.

**Aëdes (Finlaya) albilabris,** Edw.

This was not quite so common as *A. albolineatus*, though usually found in association with it. It was only found in the eastern islands, although it very probably occurs also in the west. I was never bitten by it. Specimens obtained from tree-holes at Tenaru and Manaba were preserved. Others were reared from larvae found in a tree-hole at Roviana by Mr. E. G. Sayers.

**Aëdes (Finlaya) kochi,** Dön.

A single specimen, probably this species, was seen at Malaulalo, 4.ix, but not captured. Single specimens of two species of this group have since been received from Mr. E. G. Sayers (see notes below).

**Aëdes (Aëdimorphus) imprimens,** Walk.

This mosquito is one of the most abundant species in the eastern part of the group, but was not seen at all in the Russel Group, nor further to the west. Specimens from Ilu and Kookoom were preserved, but only females were captured and the early stages were not discovered. In life the body had an olive-green tint.

The species occurred in large numbers in the forest and fed voraciously by day. Owing to its large size and long proboscis it readily bit through shirt and stockings, becoming exceedingly annoying when any halt was made. It also bit by day

occasionally in the marginal parts of plantations, but was absent at a distance of more than 300–400 yards from the edge of the forest; this seems to point to the fact that it breeds exclusively in some shaded forest habitat.

**Aëdes (Aëdes) funereus** var. **ornatus,** Theo.

This is perhaps the most generally distributed and abundant species of *Aëdes* in the British Solomons. Among other places it was found at Ilu and Tenaru, Guadalcanar; Banika; Manaba plantation, Malaita; and Lady Lever plantation, Kulambangra. Its early stages were found exclusively in temporary rain-water pools on the ground; either shallow grassy pools, muddy ditches, or water collected in hoof-marks. Owing to the similarity in their structure and mode of occurrence, its larvae were at first taken to be those of *A. vexans.*

I was not bitten by this species in the house, but while examining a rather large pool in a shallow depression on Banika plantation (Russel Group), large numbers of these mosquitos settled on me and bit during the afternoon. They were resting in the grass surrounding the margin of the pool, and, owing to the fact that no larvae were seen in the pool at the time, it seems probable that the eggs are laid on blades of grass and hatch after such pools become swollen by rain. A much smaller rain-water pool in grass at Lady Lever Estate was swarming with the larvae and pupae of this species, gradually concentrated into a smaller and smaller volume of water as the pool shrank each day (Plate xiv, fig. 2).

**Aëdes (Aëdes) carmenti,** Edw.

Females of this species were obtained biting in bush at Ilu, Guadalcanar, 26.viii, and at Ugie, 2.ix; also biting in mangrove swamp at Kaylan, Cape Marsh, 29.ix. No males were captured, and the early stages were not found, but presumably the species breeds in pools, or possibly in crab-holes in the mangrove area.

**Aëdes (Skusea) longiforceps,** sp. n.

A single male was caught from a crab-hole at Kaylan, Cape Marsh, 29.ix.

**Lutzia halifaxi,** Theo.

Larvae were found associated with *Culex annulirostris* in a small pool in the rocks just above high tide mark at Su'u, Malaita, 9.ix. The water in the pool did not taste salt, but smelt salt after evaporation.

**Culex annulirostris,** Skuse.

The occurrence of this species in association with *Anopheles punctulatus* and *Lutzia halifaxi* has already been mentioned. Its larvae were also found with *Aëdes funereus* in a rather large and shallow rain-water pool containing dead coconut leaves just above the beach at Manaba plantation, Malaita, 10.ix.

**Culex sitiens,** Wied.

A single specimen was collected in a bathroom at Tenaru, 23.viii.

**Culex fatigans,** Wied.

No adults were seen or collected anywhere. A large number of *Culex* larvae, almost certainly of this species, were seen in a barrel containing dirty water beside a Chinaman's house in Tulagi. The water had been emptied out when the locality was revisited with collecting gear, so that absolute determination was not made. It seems strange that this species, already reported from Tulagi in 1923, has not spread more through the islands. Apparently suitable breeding-places were frequently met with on other islands, but not once were its early stages found.

**Culex (Lophoceratomyia) fraudatrix,** Theo., var. **solomonis,** nov.

Larvae and pupae were found in a tree-hole at Tenaru with other species listed under *Aëdes albolineatus*. Two males and a female were reared.

**Culex (Lophoceratomyia) hilli,** Edw., var. **buxtoni,** Edw.

One male specimen, apparently of this variety, was collected under a mango tree at Banika with *Uranotaenia albescens*.

**Culex (Culiciomyia) papuensis,** Taylor.

I did not meet with this species, but specimens were reared from larvae found by Mr. E. G. Sayers at Roviana in 1929, in coconut husks, associated with *Uranotaenia quadrimaculata*, *Aëdes variegatus*, *A. argenteus*, *A. albolineatus* and *Armigeres malayi* var. *breinli*.

### 3. *Descriptive Notes on the Material.*

(F. W. Edwards.)

The material collected by Paine includes examples of two new species and two new varieties, besides the hitherto unknown larvae and pupae of several other species. The types of the new forms have been placed in the British Museum collection.

**Rachionotomyia solomonis,** Edw.

Larva (fig. 1).—*Head* rather large, rounded, pale in colour. Clypeal spines moderately stout. Dorsal hairs all rather far forward: *A*, *B* and *C* in a slightly convex line at about level of insertion of antennae, *B* almost equidistant from and slightly in front of *A* and *C*, *d* placed much further forwards, almost directly in front of *C*; *A* always simple, *B* and *C* double or occasionally triple; *d* as long as *A*, *B* or *C*, simple or double; *e* small and simple. *Antennae* not half as long as head, almost cylindrical on basal two-thirds, but with outer margin somewhat concave, apical third tapering; at two thirds of the length of the antenna on its inner aspect is a stout spine-like bristle (almost as thick as the clypeal spines) which is usually bifid near its middle. *Mentum* with a very prominent central tooth and about nine on each side. *Maxillae* longer than broad, somewhat narrowed apically, with about ten slender teeth along inner margin and a tuft of 15—20 bristly hairs at tip; palp about half as long as maxilla itself. Mandible very much as figured by Howard, Dyar and Knab for *Wyeomyia sororcula*; round basal portion without denticles.

*Thorax* with numerous stellate tufts each composed of about 10 slightly plumose branches; six of these occur on middle of dorsum of the thorax, a pair on each of the three divisions, prothoracic pair rather close together and set in small chitinous plates. Mesothorax laterally with a stout trifid spine set in a rather large plate; upper division of spine about twice as long as middle division, which again is about twice as long as lower division. Between the spine and the dorsal stellate tuft of the mesothorax is a group of four single hairs set separately in small plates, the outermost of these hairs much longer than the others. Metathorax with a trifid lateral spine similar to that of mesothorax, but longer and even stouter. Pleural hairs*: Prothoracic anterior dorsal moderately long, double; anterior ventral slightly longer, single; posterior dorsal very short, single; posterior ventral nearly twice as long as anterior, single. Mesothoracic anterior dorsal very long, 4-branched; anterior and posterior ventral of the same length, single; posterior dorsal very short, single. Metathoracic anterior dorsal very long, 6-branched; anterior ventral still longer, single; posterior dorsal and ventral both short, single.

*Abdomen* with numerous large stellate tufts similar to those of thorax, dorsally, laterally and ventrally, each tuft with about 10 branches; on dorsum of each segment

* See Puri's paper in Ind. Journ. Med. Res. xvi. 1928, p. 519.

four such tufts are present, except that the eighth segment has only two. Eighth segment with lateral plates well chitinised ; comb of 8–10 long, sharp teeth, of which the lowermost three or four are smaller and placed closer together. *Siphon* short, dark, narrow at tip, index about 2·5. Dorsally and dorsolaterally are a few rather short, irregularly arranged double hairs ; ventrally close to base is a pair of rather short triple hairs, and more distally a slightly irregular mid-ventral row of about

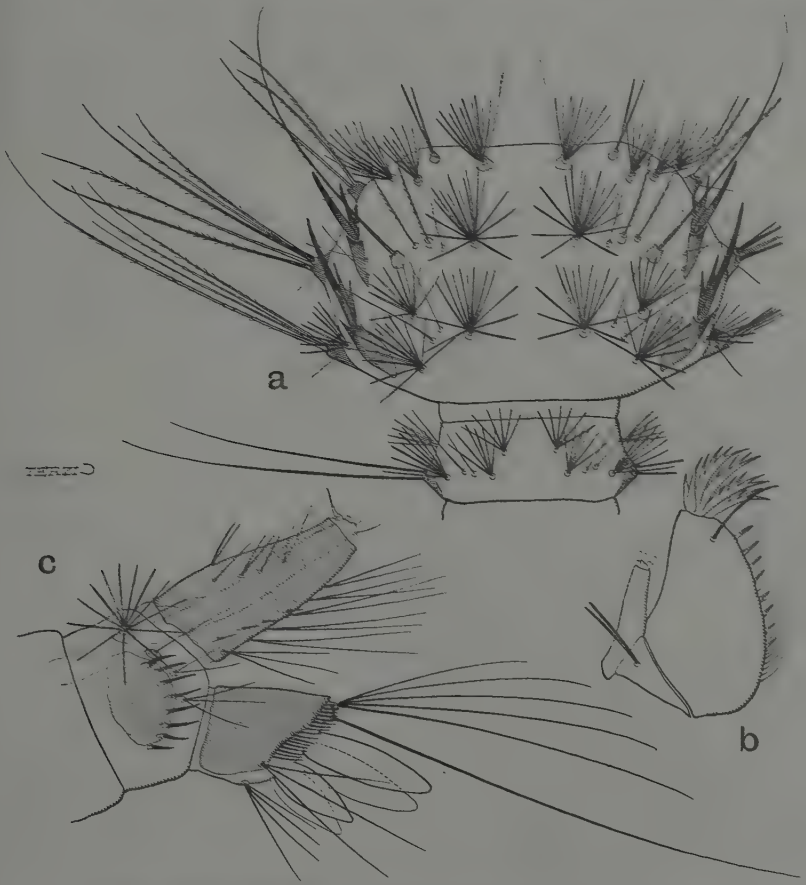



Fig. 1. *Rachionotomyia solomonis*, Edw., larva : *a*, thorax and 1st abdominal segment, from above ; *b*, maxilla ; *c*, tip of abdomen, from side.

six double hairs each of about the same length as the siphon. Dorsal valves with a rather strong spine, ventral valves with a single hair. Pecten of four or five simple, widely spaced teeth. *Anal segment* with rather large saddle, with about 20 needle-like teeth on each side posteriorly. Outer dorsal hair single, inner 6-branched ; ventral tuft 5–6-branched ; lateral hair of saddle long, stout, double or triple. Gills fusiform, pointed, upper pair slightly longer than saddle, lower about half as long as upper.

PUPA.—Very similar to that of *R. caledonica* as described and figured by Bux[illegible] (Researches in Polynesia and Melanesia, p. 75), but lateral tuft of eighth segm[illegible] longer than the segment itself; paddles relatively small, not extending beyond e[illegible] of tuft of eighth segment; and submedian hairs on posterior margin of tergi[illegible] 3–7 smaller.

In the morphology of its early stages *R. solomonis* proves to be a typical *Rachiotomyia*, although the larva is well distinguished from most others known by the st[illegible] antennal bristle and the strong trifid spine of the mesothorax, as well as by the fo[illegible] of the teeth on the maxilla and other details. We must therefore conclude that [illegible] adult features of comparatively short proboscis and long male palpi, which distingu[illegible] this species and *R. atripes* from the genotype, are of secondary importance on[illegible] The larva of *R. atripes* has been described by Cooling (1924) and is evidently v[illegible] similar to that of *R. solomonis*, but the stout antennal bristle is simple and the lar[illegible] spines of the comb are blunt-ended.

**Rachionotomyia (Rachisoura) filipes** (Walk.).

LARVA (fig. 2).—*Head* large, somewhat longer than broad, pale in colour. Clyp[illegible] spines long, moderately stout. Dorsal hairs rather far forward: *A* and *B* near le[illegible] of insertion of antennae, *C* almost directly behind and at a rather great distan[illegible] from *B*, *d* in front of and well inside *B*; *A*, *B* and *e* double, *C* and *d* simple, *C* muc[illegible] longer than the others. *Antennae* short, cylindrical, about four times as long a[illegible] broad, with a fine single hair on outer side near tip. *Mentum* broad and shor[illegible] central tooth and last but one on each side prominent; about seven teeth on ea[illegible] side of central tooth. *Maxillae* of very remarkable form: main portion about hl[illegible] as long again as broad, not much narrowed apically, with about five short, broa[illegible] teeth on inner margin and one additional tooth ventrally; at apex of maxilla a[illegible] two strong articulated hooks, the larger hook as long as the maxilla itself, the smal[illegible] a little more than half as long; at the base of the smaller hook are a number o[illegible] small spinules which perhaps represent the tuft of bristles found in other specie[illegible] Palp almost as long as main portion of maxilla, the whole structure closely simil[illegible] to the maxilla of *Lesticocampa rapax* as figured by Howard, Dyar and Knab. Mandible very similar to that of *L. rapax*, with a number of small teeth on the basal rounde[illegible] portion.

*Thorax* bare in middle, without conspicuous stellate tufts. On prothorax th[illegible] innermost pair of tufts are only triple and set very far apart. Mesothorax laterally with a group of five single hairs close together, one very much longer than the other[illegible] none in the least spine-like. Metathorax without dorso-lateral spine, the place of this being taken by a large 8–10-branched tuft, the branches long, slender and plumose; chitinous plate at base of tuft very small. Pleural hairs somewhat as in *R. solomonis*, but prothoracic anterior dorsal with about four branches; mesothoracic anterior dorsal scarcely longer than prothoracic and about 6-branched; metathoracic posterior dorsal quite five times as long as the posterior ventral, which is very minute.

*Abdomen* without stellate tufts; dorsum of first segment bare except for a sub-lateral pair of small chitinous plates, each of which includes the bases of two hairs, the anterior double, the posterior 3–4-branched, the branches rather stout; on remaining segments there is only one short sublateral hair, usually 4-branched. Eighth segment without chitinous plates; comb of 7–9 strong, pointed teeth, each with a pair of strong basal denticles. *Siphon* short, black; posterior margin straight, anterior margin parallel with posterior for a short distance, then converging, so that tip of siphon is not more than one third the diameter of the base. A dorsal row of 8–10 hair-tufts, each 3–4-branched and about as long as basal diameter of siphon; a ventral row of 11–14 hair-tufts, each 3–4-branched and almost as long as length of siphon. Pecten of about 7 sharp, simple teeth, first tooth at one-fourth, last at

three-fourths length of siphon ; an additional tooth at extreme tip of siphon. Dorsal valves with a stout bristle, ventral valves with a long 4-branched hair. *Anal segment* with rather small saddle, with a group of 4–5 stout teeth on each side posteriorly. Outer dorsal hair single, inner 7–8-branched ; ventral tuft long, 6–7-branched ; lateral hair of saddle long, stout, simple. Gills very long, slender, pointed, dorsal pair nearly four times as long as saddle, ventral pair not much shorter.

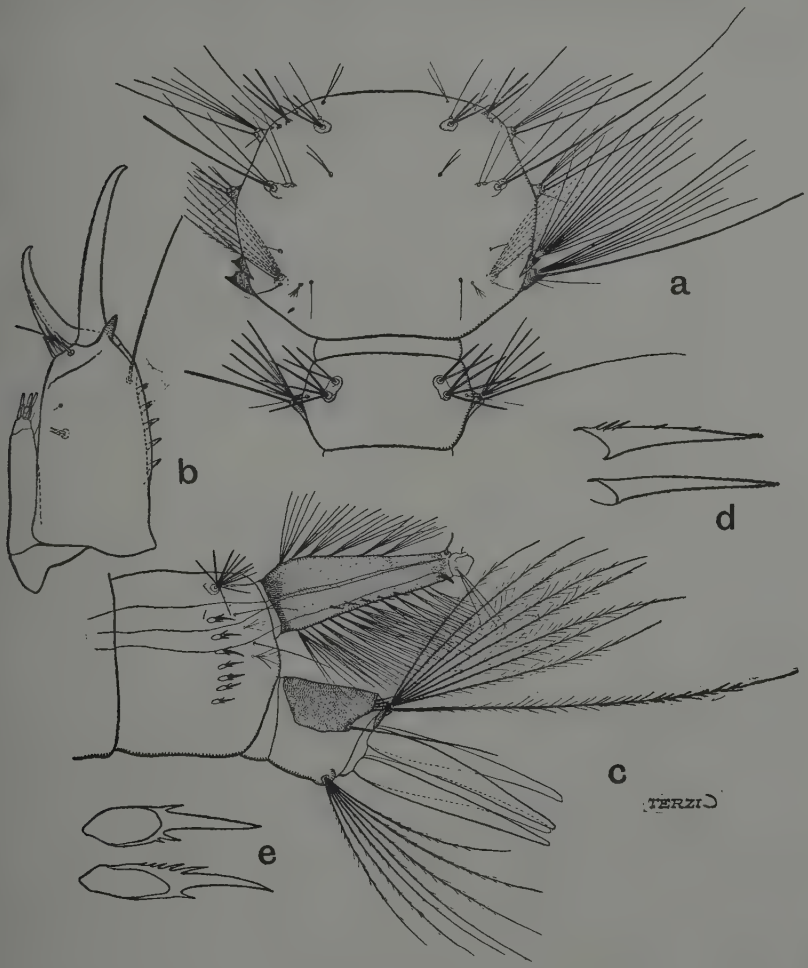



Fig. 2. *Rachionotomyia filipes*, Walk., larva : *a*, thorax and 1st abdominal segment, from above ; *b*, maxilla ; *c*, tip of abdomen, from side ; *d*, pecten teeth ; *e*, comb teeth.

Pupa.—Very similar to that of *R. solomonis*, but respiratory horn longer, about 2·2 instead of 1·3 times as long as its greatest breadth.

In many respects the larva described above is very different from all other *Rachionotomyia* larvae hitherto discovered, notably in the form of the maxillae,

the very slight development of stellate tufts on the thorax and abdomen, a absence of the metathoracic spine. These distinctions are so very pronou after studying these larvae I was led to re-examine the adults in the superf finding some character that might lead to the exclusion of the species in th *Rachionotomyia*. The closest scrutiny however has failed to reveal any th which distinguishes the adult *R. filipes* from all other species of the genus, the presence on the postnotum of from one to three minute bristles. These are so small that they have previously been overlooked, and it may be doubted whether they are constantly present.

The divergence of *R. filipes* larva from other *Rachionotomyia* is not as great than the resemblance it shows to the tropical American genus *Pseudo-Limnophora* especially in the structure of the maxillae. Both *R. filipes* and *Pseudo-Limnophora* are known to be predacious, and the maxillae are evidently modified for the purpose of capturing their prey. The similarity in form of these organs may therefore be due to convergence brought about by similar habits; but it should be noted that *Sabethines*, another allied American genus which has adopted a predaceous mode of life and has used its maxillae further than any other organs for purposes of prehension, has modified them in a different way. It seems, therefore, more probable that the resemblance between *R. filipes* and *Pseudo-Limnophora* implies a real relationship although how the two genera are connected cannot at present be determined. More light will be thrown on the matter when the larvae of some of the many species of *Pseudo-Limnophora* recently found in New Guinea are made known. Meanwhile it may be justifiable to revive Theobald's name *Paulianomyia* for this species, treating it provisionally as a subgenus of *Rachionotomyia*.

**Uranotaenia argyritarsis.** Lec., var.

♂. *Head* black-scaled in middle, with a broad blue border [illegible]. Proboscis slightly longer than abdomen, very much swollen [illegible], [illegible] short hairs above towards tip. *Palpi* dark. Terminal joint [illegible] twice as long as penultimate, latter not [illegible] as long as antennal [illegible]. *Thorax* dark brownish with [illegible] and dark brown [illegible] conspicuous tips of flat blue scales at front of [illegible]. *Pleurae* [illegible] with pale blue scales. [illegible] as a white oblique line without scales [illegible]. *Abdomen* [illegible] base the medial longitudinal [illegible] white apical patch on the fourth [illegible] and a few white [illegible] *Legs* mainly dark brownish, [illegible] tibiæ and last tarsal segment are lighter brown. The last four [illegible] cream-coloured. *Hind legs* the last three tarsal segments [illegible] are pure white. *Fourth segment* of middle tarsus [illegible] somewhat thickened. *Hind tibiæ* slightly [illegible] at their origin, narrowing before the apex, [illegible] so the apex seems two-lobed beneath. *Wings* with the [illegible] front of base pale. *Wings* with the scales mainly dark [illegible] of radius with white scales [illegible] of cubitus. *Upper forceps* [illegible] 2·5 mm.

♀. *Eyes* [illegible] *Antennæ* [illegible] *Scutum* [illegible] *Abdomen* [illegible] *Segments* [illegible] *Segments* [illegible] long as the [illegible] *Segments* [illegible]

with a transverse black line at base, somewhat pointed in shape ; apical fringe very fine and indefinite on outer portion, more obvious on inner portion. Apparently no hair at tip of midrib.

Many of the characters noted above, particularly the peculiar formation of the hind tibia, were not mentioned by Leicester in his description of the male, but the specimen before me agrees rather closely with Leicester's types. The most obvious difference, perhaps indicating that the Solomons form is varietally distinct, is that the tip of the second hind tarsal segment is white as well as the whole of the last three segments ; in this respect the male from the Solomons agrees with a female from New Britain. This last specimen further differs from Leicester's female in having the white scales of the abdomen confined to the third and fourth tergites, as in the male of both forms.

**Uranotaenia quadrimaculata,** sp. n.

♂♀. *Head* clothed with bluish-grey scales without markings. Proboscis about same length as abdomen, scarcely swollen at tip, entirely dark. Palpi dark. Antennae of ♂ with last two segments subequal in length, each longer than the three preceding together. *Thorax* with ground-colour mainly yellowish brown; pleurae lighter, pale yellowish. Prothoracic lobes pale yellowish, with scales of the same colour. Scutum with black bristles and narrow blackish-brown scales ; no broad flat scales on front margin or in front of wing-roots. A rather large roundish black spot immediately in front of each wing-root, the area occupied by this spot bare of scales ; on upper margin of spot a row of whitish scales which are slightly longer and broader than those on remainder of scutum ; above this row of scales is a bare area of clearer yellow integument, emphasising the black spot to which it forms a border. Scutellum brownish with dark brown scales as usual. Postnotum dark brown, paler at sides. Posterior pronotal lobes (proepimera) pale yellowish in front, posterior half or more occupied by a large black spot. Pleurae pale yellowish, unmarked, and apparently devoid of scales. *Abdomen* entirely blackish. *Legs* dark brown, without any special modification in ♂. *Wings* without any white scales ; on veins at tip of wing the scales are rather broadly oval. Upper fork-cell in ♂ not one-third as long as its stem. Wing-length, 2·5 mm.

Larva.—Closely resembles that of *U. obscura* Edw. (described in Bull. Ent. Res., xviii, p. 338, 1928), and like it having the chitinous plates of the eighth segment connected by a dorsal saddle, a character at present known only in these two species. The only distinctions from *U. obscura* in the two specimens before me are that the head is paler in colour; the siphonal and subsiphonal tufts have only two instead of four branches ; and the comb-teeth have no basal fringe.

Pupa.—Respiratory trumpet short, only about twice as long as its greatest breadth; on the middle of its inner margin is a small semicircular emargination. Hair behind trumpet 3–4-branched. Abdominal segment 2 with two strong simple bristles placed close together towards each side. Segments 3–7 each with a short stiff bristle laterally, somewhat behind the posterior corner, and a simple sublateral bristle, about two-thirds as long as the segment, on posterior margin ; remaining bristles on these segments minute and inconspicuous, except that segment 7 has an additional simple bristle at the posterior corner. Lateral apical bristle of eighth segment simple or bifid. Paddle with the part within the midrib much larger than the outer part, also more extended apically, where it is provided with a loose fringe of spinules ; on outer part of paddle the spiny fringe is much shorter and closer. A small simple hair placed at apex of midrib, and a longer one slightly external to this.

In the possession of two conspicuous black spots on each side of the thorax, one on the posterior pronotum and the other in front of the wing-root, this species resembles *U. nigerrima*, Taylor. No other species of the genus known to me show

similar markings ; *U. mashonaensis*, Theo., and *U. bimaculata*, Leic., have the second of the two black spots, but lack the first. The Solomons specimens were at first thought to be merely rather light-coloured examples of *U. nigerrima*, but a closer examination revealed differences which seem to be specific. The British Museum possesses specimens of *U. nigerrima* in perfect condition from Rabaul, New Britain (*Heydon*), and others (damaged, but obviously conspecific with the first) from Milne Bay, Papua (*Breinl*), the type locality.

These specimens show the following differences from *U. quadrimaculata* :—

Thorax much darker in general colour (not yellowish-brown as stated in Taylor's description). On front margin of scutum immediately above pronotum on each side is a patch of small, flat, whitish scales. The scales forming the whitish line above the posterior black spot are decidedly broader and more numerous ; integument immediately above these scales not lighter but rather darker brown than remainder of scutum. Posterior pronotum almost entirely black, its anterior margin only narrowly pale. Upper part of sternopleura and most of mesepimera dark brown ; lower part of pleurae with slight bluish dusting as seen from above.

The *Uranotaenia* recorded by me (1926) from Port Purvis, Gela, is *U. quadrimaculata*, not *U. nigerrima*.

**Pardomyia aurantia** var. **nigrescens,** nov.

Differs from typical *P. aurantia* as follows : Abdominal scales mainly black, the golden yellow scales almost confined to pairs of dots on each of tergites 2–4, and median patches (not very large, but extending to hind margin) on each of tergites 5–7. Legs darker, femora and tibiae with much less conspicuous yellow mottling.

Larva similar to that of the type form (described in Bull. Ent. Res., xviii, p. 341, 1928), but antennae slightly longer, and siphon distinctly longer, with index about 2·7. Pupa closely resembling that of the type form.

An error in the description of the larva of *P. aurantia* must be corrected. The comb-scales are not simple and sharp (though they appear so in side view), but are bluntly rounded and fringed at the tip.

**Armigeres malayi,** Theo., var. **breinli,** Taylor.

The larvae differ from those of *A. obturbans* in the much smaller development of the hair-tufts on the thorax and abdomen. The longer tufts of the thorax, including the long pleural hairs, have at most two branches, and the lateral tufts of the first seven abdominal segments are also only two-branched. The larvae are in almost all respects similar to some Malayan examples in the British Museum determined by Theobald as *Desvoidya fusca* (=*A. malayi*), and as the hypopygia of the two forms are also identical *A. breinli* is best treated as a variety of *A. malayi*.

**Aëdes imprimens,** Walk.

In general appearance this species resembles *A.* (*Aedimorphus*) *vexans*, Mg., but I rather strongly suspect that *A.* (*Banksinella*) *brugi*, Edw., may be the male of *A. imprimens*, in which case the species belongs to the subgenus *Banksinella*.

**Aëdes** (**Stegomyia**) **albolineatus,** Theo.

Both adults and larvae are quite similar to Oriental specimens. The larvae have been described by Brug (Bull. Ent. Res., xiv, p. 433, 1924).

**Aëdes** (**Finlaya**) **kochi** var. **samoana,** Grünb.

A single female, agreeing well with Samoan examples in regard to colouring and absence of outstanding scales on the 5th abdominal sternite, has recently been received

from Mr. E. G. Sayers by Dr. P. A. Buxton. It was captured by a nursing sister at Roviana, New Georgia, in the act of biting, at 6 a.m., 16.vi.1929. This is the first record of this variety outside the islands of the Samoan and Tongan groups.

**Aëdes (Finlaya) flavipennis,** Giles.

A single female, somewhat damaged but no doubt belonging to this very distinct species, was included in the same collection with the last, captured on a verandah at Roviana at 6 a.m. This appears to be the first record of the species from the Australasian region.

**Aëdes (Finlaya) albilabris,** Edw.

The specific name was bestowed in reference to the white patch at the tip of the proboscis in the female type. Subsequently (Bull. Ent. Res., xvii, p. 110, 1926) additional material showed that this marking is absent in the male. In the series now before me it is present only in a proportion of the females and constantly absent in the males. The species is, therefore, to be distinguished from the common Australian *A. notoscriptus* chiefly by the slight difference in thoracic marking.

Larva.—*Head* dark, especially posteriorly. Clypeal spines very stout, curved, hook-like. Hair *A* double, *B* and *C* single, *d* not traceable, *e* rather long, fine, simple. Antennae about half as long as head, slender, cylindrical, with a fine single hair at two-thirds, shaft otherwise smooth. Mentum triangular, with large central tooth and about ten teeth on each side.

*Thorax* with the dorsal stellate hairs very small and inconspicuous. Prothoracic hairs mostly rather short and simple, one of the pleural hairs double. Mesothoracic lateral tuft 4–6-branched, as is one of the hairs in the pleural group; corresponding hairs on metathorax 6–8-branched.

*Abdomen* with dorsal stellate hairs very small and inconspicuous. Lateral hairs of first three segments double, of following segments smaller, but triple. Comb of about 25 scales, rather long, but blunt-ended and finely fringed. *Siphon* short, dark, index about 1·3. Pecten of about 8 teeth extending to nearly two-thirds, teeth with strong basal denticles; tuft 3–4-branched, at level of and inside end of pecten. *Anal* segment with large saddle, fringed on upper part of posterior margin, with about 8 teeth on each side, below which are some fine short denticles. Lateral hair missing in all specimens examined. Gills about half as long again as saddle, lower hair shorter.

The larva is evidently very similar to that of *A. notoscriptus* as described and figured by Cooling (Commonwealth of Australia Dept. of Health, Service publication no. 8, p. 21, 1924). Its most striking feature is the unusual stoutness of the clypeal spines.

**Aëdes (Skusea) longiforceps,** sp. n.

♂. *Head* clothed above and at sides with flat scales, dark brown in colour with a purplish gloss. Eyes touching above antennae. Bristles black. Proboscis dark brown, distinctly longer than front femora. Palpi slender, about one-fifth as long as proboscis. Antennae with plumes moderately developed; last segment longer than penultimate, the two together not much shorter than remainder of antenna. *Thorax* with integument mainly dark brown; scutellum, pleural sutures, and metapleura (behind mesothoracic spiracle) pale yellowish. Scales of scutum and scutellum narrow, dark brown; bristles black. Pronotal lobes (anterior and posterior) with small dark flat scales. Sternopleura with whitish scales posteriorly, and rather numerous short pale hairs below, bristles black. Mesepimera with the bristles of the upper tuft black, a small patch of whitish scales adjacent to them; lower half without scales or bristles, but with some fine pale hairs posteriorly. *Abdomen* dark brown above, tergites with small basal lateral creamy-white patches. Hypopygium:

side-pieces over three times as long as broad, somewhat narrowed in middle (on dorsal margin) without basal or apical lobes, but with a small patch of hair at base. Clasper strap-shaped, but rather rigid, with long slender terminal spine inserted at right angles to its main axis. Ninth tergite with small lobes, each with two or three short bristles. Ninth sternite small, pubescent. Mesosome short, scoop-shaped, as in the subgenera *Ochlerotatus* and *Finlaya*. *Legs* dark brown, femora pale beneath. Front coxae with dark brown scales, posterior coxae with fewer and lighter scales. Hind tibiae normal, without fringe, bristles few and short. Hind claws simple. *Wings* with dark scales, outstanding scales on outer veins narrow. Bases of fork-cells almost level, upper about as long as its stem. Wing-length 2·8 mm.

This species is evidently closely allied to *A. fimbripes*, Edw. (New Britain) and *A. tonsus*, Edw. (Amboina), from both of which it differs in the narrow scutellar scales and in details of the hypopygium, also from *A. fimbripes* in the simple hind tibia. These three species together form a rather well-marked group which is not clearly related to any of the other species-groups included in the subgenus *Skusea*, but on the other hand has several points in common with the subgenus *Pseudoskusea*, notably the long terminal spine of the male clasper and the simple, scoop-shaped mesosome.

**Aëdes (Aëdes) funereus,** Theo., var. **ornatus,** Theo.

The larvae and skins preserved are somewhat damaged, and a complete description cannot be given, but they appear rather closely similar to *A. umbrosus*, Brug (described in Bull. Ent. Res., xviii, p. 345, 1928). Points of difference are that clypeal hair *C* is distinctly internal to, instead of directly behind *B*, and is 5-branched (in one specimen at least); also the dorsal (but not the lateral) margin of the anal saddle is fringed with short spicules. As in *A. umbrosus*, the last few pecten-teeth are rather widely detached, a point which was not mentioned in the description.

**Culex (Lophoceratomyia) fraudatrix** var. **solomonis,** nov.

Differs from the type form in having the scales on the sixth antennal segment reduced in number to about six; they are also rather shorter, but broad as in the type, not hair-like as in *C. hilli*; side-pieces of male hypopygium without any long or longish hairs ventrally towards base (the type form has always three such hairs).

Larva much as in the type form; siphonal index about 7·5.

## Explanation of Plate XIII.

Fig. 1. Fresh-water pool fed by a spring, Banika, Russel Group.

Fig. 2. Hoofmarks containing *Anopheles* and *Culex annulirostris*, Vila Estate, Kulambangra.

1

2

## Explanation of Plate XIV.

Fig. 1. Shallow ditch with water in hoofmarks, Lady Lever Estate, Kulambangra.

Fig. 2. Temporary rain-water pool, Lady Lever Estate, Kulambangra.

1

2

# MOSQUITO NOTES.—VIII.

By F. W. Edwards.

Contents.


| | | PAGE |
|---|---|---|
| I. | Some varieties of African and Oriental *Anopheles*... ... ... ... | 321 |
| II. | New and little-known African Culicines ... ... ... ... ... | 324 |
| III. | The larvae and pupae of *Eretmopodites* ... ... ... ... ... | 328 |
| IV. | The larva and pupa of *Mimomyia plumosa*, Theo. ... ... ... | 332 |
| V. | The larva and pupa of *Culex moucheti*, Evans ... ... ... ... | 333 |
| VI. | New species collected by Mr. R. W. Paine in Fiji ... ... ... | 337 |
| VII. | The forms referred to the subgenus *Skusea* of *Aëdes* ... ... ... | 340 |
| VIII. | The value of the squamal fringe as a generic character ... ... ... | 342 |


## I. Some Varieties of African and Oriental *Anopheles*.

### *Anopheles rufipes*, Gough, and *A. theileri*, Edw.

These species, together with *A. brunnipes*, Theo., have been referred to the *Neocellia* group of the subgenus *Myzomyia* on account of the broad mesonotal scales, and (in the case of the first two species mentioned) of the broadly white-tipped hind tarsi. The three species, however, differ from the other members of the *Neocellia* group in the possession of a distinct propleural hair, whereas the other African species (*A. maculipalpis*, Giles, and *A. pretoriensis*, Theo.) agree with all the Oriental species of the *Neocellia* group in having no propleural hair. It is therefore probable that the first three species are to be regarded as members of the *Myzomyia* group in which the ornamentation is unusually well developed. This conclusion, arrived at from an examination of the adults, is confirmed by a study of the larvae; Christophers informs me that the larvae of *A. theileri*, which have been examined by himself and Puri, have pleural hairs of the *Myzomyia* type. It is also suggestive that *A. rufipes* and *A. theileri* are both variable in wing-markings and thoracic scaling, and as in the case of *A. marshalli*, some variations appear to be definitely fixed. Some of these variations are described below as new varieties.

*A. rufipes* and *A. theileri* are in many respects very similar, but may be distinguished in all their varieties by the three following characters: (1) The mesonotal scales are much broader in *A. rufipes*, the broadest being only about three times as long as their greatest breadth, whereas in *A. theileri* they are more hair-like, the broadest being at least eight times as long as broad; also, *A. rufipes* has a distinct row of broad flat scales extending forwards in front of each wing-base, this row being absent in *A. theileri*; (2) The front and middle tarsi of *A. rufipes* are either entirely dark, or the first two front tarsal segments faintly white-tipped, whereas the first three segments of front and middle tarsi of *A. theileri* are conspicuously white-tipped; (3) The pale wing-scales of *A. rufipes* are pure white, whereas in *A. theileri* they have a distinct yellowish tint.

On the basis of the above distinctions, two forms of *A. rufipes* and four of *A. theileri* may be distinguished in the British Museum material; four of these are described as new below. It is noteworthy that a parallel variation in the markings of the hind tarsi occurs in the two species.

**Anopheles rufipes,** Gough, type form.

This was described from Onderstepoort, Transvaal, as a variety of *A. pretoriensis*, Theo. A full description was not given by the author, and I have seen no specimens

from the type locality, but assume that the form I described as *A. watsoni* is the same as the Transvaal type. This is characterised by having the first two segments of the hind tarsi very distinctly white-tipped ; third hind tarsal segment with a black ring of variable width, usually occupying from half to two-thirds of the total length of the segment (rarely less) and sometimes leaving the base narrowly white ; last two segments all white. Wing-markings rather variable, especially in the amount of white on the third vein, which may be absent or may occupy more than half the vein ; sixth vein with outer half dark, and with a dark spot towards base ; stem of upper fork mainly dark.

TRANSVAAL (*Gough*). RHODESIA : Bindura (*Haworth*). KENYA : Masongaleni (*Neave*). SUDAN : Medani (*W. Cameron*). NIGERIA : Minna (*Simpson*) ; Katagum (*Watson*).

**Anopheles rufipes** var. **ingrami,** nov.

Hind tarsus with the first segment dark to the tip, second rather broadly white apically, last three all white, the third occasionally with a narrow dark basal ring. Wing-markings as in *A. rufipes,* type form.

GOLD COAST : Bole, 1911 (*A. Ingram*), type ♀, paratypes 3 ♂ 3 ♀ in British Museum. NIGERIA : Zungeru, x–xi.1915 (*Dr. W. B. Johnson*), 2 ♂ with first hind tarsal segment very narrowly pale at tip.

**Anopheles theileri,** Edw., type form.

First hind tarsal segment narrowly but very distinctly, secondly broadly white at tip ; third narrowly black at base. Wings with costa black on basal half, without pale interruptions near base ; a large yellow area above stem of upper fork. Veins largely yellow-scaled ; stem of upper fork entirely yellow, also most of the upper branch ; dark spot at base of fifth vein small or absent ; sixth vein with two or three small dark spots.

TRANSVAAL : Onderstepoort (*Gough*). BELGIAN CONGO : Elisabethville (*Schwetz*).

**Anopheles theileri** var. **brohieri,** nov.

Hind tarsi as in type form, but black ring on third segment broader (perhaps variable individually). Wings less extensively yellow ; costa with two pale interruptions near base, but yellow area above stem of upper fork less extensive ; stem of upper fork entirely yellow, but dark area at base of fifth vein longer and sixth vein mainly dark on apical half.

GOLD COAST : Wa, 1921 (*Dr. E. L. Brohier*), type and one other ♀.

**Anopheles theileri** var. **hancocki,** nov.

Hind tarsi with first segment entirely black, second rather broadly white at tip, last three all white. Wings largely dark ; costa with two narrow pale interruptions near base ; one or two dark spots on stem of upper fork ; fifth vein with a long black spot near base ; outer half of sixth vein mainly dark.

UGANDA : Kampala, 8.i.1929 (*G. L. R. Hancock*), type ♀, allotype ♂. NIGERIA : Oshogbo, x–xii.1910 (*Dr. T. F. G. Mayer*), 2 ♀.

**Anopheles theileri** var. **seydeli,** nov.

Hind tarsi with first segment rather broadly white at tip, second narrowly white at base and more broadly at tip, third broadly white at base and tip, fourth white with a narrow black ring in middle, fifth white. Wings as in var. *hancocki* ; sixth vein with apical half black-scaled.

BELGIAN CONGO : La Lunga, Katanga, 12.iv.1925 (*Ch. Seydel*).

*Anopheles gigas*, Giles.

Christophers (Ind. Journ. Med. Res., xii, 1924, p. 12) has noted the distinctions between the typical South Indian form of this species and the Himalayan var. *simlensis*, James; he also indicated the probability that the races inhabiting other mountainous parts of the Oriental region would be found to be distinct. This certainly seems to be true in at least the following two cases.

**Anopheles gigas** var. **refutans,** Alcock.

The British Museum possesses two females of this variety from Maskeliya, Ceylon. These resemble the typical form in wing markings and in having only a small pale spot at the tip of the middle femur above, but differ not only, as stated by Alcock and Christophers, in having the tips of the palpi pale, but in having no pale spots in the fringe on the outer half of the wing, the only pale fringe-spot being one situate just basally to the lower branch of the fifth vein, which is present in all varieties. The dark fringe of the Ceylon form has also been noted by Carter (Ceylon Journ. Sci., D, i, p. 69).

**Anopheles gigas** var. **baileyi,** nov.

Resembles the var. *simlensis* in having three narrow white rings on the black-tipped palpi, no white scales on the sixth vein, and a large white spot at the tip of the middle femur above, but differs in having the fringe on the apical part of the wing entirely dark and the two outer dark costal spots more or less completely fused (though there is a small pale spot on the first vein below the point at which the two costal spots are nearly always well separated in var. *simlensis*). As in var. *simlensis*, the middle and hind femora have white rings at the base which are about twice as wide as the femoral diameter (in the type form and var. *refutans* these rings are much narrower).

Tibet: Yatung, 10,000 ft., ix.1927 (*Lt.-Col. F. M. Bailey*), type and one other ♀ in British Museum, reared from larvae found in company with those of *Culex mimeticus*, Noé. W. China: Golden Buddha Mt., Chin-Fu-San, N. of Chungking, 5,000 ft., 12.viii.1907 (*W. A. Maw*), 1 ♀.

*Anopheles lindesaii*, Giles.

Christophers (Ind. Journ. Med. Res., xiii, 1926, p. 876) has distinguished between the type form of this species inhabiting Northern India, the var. *nilgiricus*, Chr., of Southern India, and the var. *japonicus*, Yam. (*pleccau*, Koidzumi) of China, Japan and Formosa. The species has also been recorded from the Malay Peninsula by Hacker, and the specimens in the British Museum show slight differences from any of the other varieties as noted below.

**Anopheles lindesaii** var. **cameronensis,** nov.

Resembles the var. *japonicus* in regard to wing-scaling (scales if anything broader), but front and middle femora with distinct white basal rings about equal in width to femoral diameter (no such rings being present in var. *japonicus*) and white area at base of hind femur forming a distinct ring about two-thirds as broad as the distal ring, the dark colour not extended towards the base dorsally as it is in var. *japonicus*.

Malay Peninsula: Cameron's Highlands, 5,000 ft., 1923 (*Dr. H. P. Hacker*), type ♀ and allotype ♂ in British Museum.

*Anopheles hyrcanus*, Pall.

This is a very variable species, both individually and locally, and is still not well understood. Christophers has attempted to distinguish several varieties, but the characters which he gives are not very satisfactory, and I would suggest the following alternative definition of the chief local forms which occur.

**Anopheles hyrcanus** var. **pictus,** Lw.

Hind tarsi with narrow pale rings at apices of segments only. Wing markings usually clearly defined, without admixture of light scales over the dark areas. Dark mark near base of fifth vein long. Palestine, Macedonia, Mesopotamia.

**Anopheles hyrcanus** var. **pseudopictus,** Grassi.

Hind tarsi with narrow pale rings at apices of first three segments, fourth wholly white or whitish. Italy, Macedonia, Caspian region. This is not a purely geographical form; it may be a distinct species, but is more probably a colour variant of var. *pictus*.

**Anopheles hyrcanus** var. **mesopotamiae,** Chr.

Hind tarsi as in var. *pictus*. Wings with markings suffused, but dark mark at base of fifth vein long, as in var. *pictus*. Mesopotamia.

**Anopheles hyrcanus** var. **sinensis,** Wied.

Hind tarsi as in var. *pictus*. Wings usually paler than in var. *pictus*, dark areas variable and sometimes suffused, but dark spot near base of fifth vein short, usually dot-like. China, Japan, Formosa, Malay Peninsula. Possibly widely distributed also in India, but I have seen only one Indian specimen (from Ukhrul, Manipur) which seems referable to this variety.

**Anopheles hyrcanus** var. **nigerrimus,** Giles (**peditaeniatus,** Leic.).

General colour of body much blacker than in the other varieties. Rings of hind tarsi broader, the fourth segment more or less conspicuously white at base as well as at tip. Giles' type of *A. nigerrimus* had lost its hind tarsi when described, and both it and Theobald's type of *A. minutus* are unusual in having the outer half of the sixth vein wholly dark, instead of with two dark spots, but as this seems to be the common Indian form, Giles' name may safely be used for it. British Museum material is from India, Ceylon, Malay Peninsula, Borneo, Siam, and the Philippine Is. If Leicester was correct in noting a definite difference between the larvae of *A. hyrcanus* (*sinensis*) and *peditaeniatus*, the two may just possibly prove to be distinct species.

## II. New and Little-known African Culicines.

**Aëdes (Aëdimorphus) phyllolabis,** sp. n.

Closely allied to *A. tarsalis*, Newst., differing mainly, if not solely, in the form of the male claspers (fig. 1, *a*), which are more broadly expanded apically, much as in *A. minutus*, Theo., and lack the strong dorsal spine of *A. tarsalis*; in addition to the subapical spine and leaf-like appendage, the claspers carry only four minute hairs, thus differing from the claspers of *A. minutus*, which are extensively pubescent. Side-piece without basal lobe and without the small apical group of very long hairs which occurs in *A. minutus*. Scales of scutellum of ♂ all broad and pure white; of ♀ somewhat variable, the middle lobe in many specimens carrying some narrow black scales apically, and a variable number of narrow creamy scales basally; the broad scales which form the main clothing of the scutellum of the ♀ are rather smaller than in the ♂ and more creamy in tint. White spot at tip of hind tibia rather more extensive than usual in *A. tarsalis* (fully twice as long as tibial diameter). As in *A. tarsalis* the scales on the upper part of the head are all narrow; the pale scales of the scutum tend to be collected round the margin and in a pair of round discal spots; the abdomen is dark dorsally in the ♀ but has complete silvery-white basal bands in the ♂.

Belgian Congo: Stanleyville, viii–ix.1928 (*Dr. J. Schwetz*); a series reared from larvae; type ♂, paratypes 20 ♂ 18 ♀, in British Museum.

The variation in scutellar scaling in the ♀ is similar to that which occurs in the related *A. albocephalus*, upon which I have previously commented. There is also a similar but less pronounced variation in *A. tarsalis*, and in Theobald's type ♀ of *Neopecomyia uniannulata* (which I have regarded as synonymous with *A. tarsalis*) the middle lobe of the scutellum bears narrow black scales apically as in many specimens of the new species. It is possible that *N. uniannulata* may be synonymous with *A. phyllolabis* rather than with *A. tarsalis*, but I am unable at present to distinguish the females of these species, and no males of the present species have been received from anywhere except Stanleyville.

**Aëdomyia furfurea** (End.).

This was described by Enderlein (Wien. Ent. Zeit., xl, 1923, p. 26), under the new generic name *Lepiothauma*, from a single somewhat damaged female said to have been taken in the interior of Kamerun. After examining the type I made the statement (Bull. Ent. Res., xv, 1925, p. 262) that *L. furfurea* was identical with *Aëdomyia venustipes*, Skuse—a matter for surprise, as *A. venustipes* had previously been reported only from the Oriental and Australian regions. I now have reason to believe that *A. furfurea* is equally distinct both from *A. africana* and *A. venustipes*, this conclusion being based upon the examination of fresh material (2 ♂, 2 ♀) from Dar-es-Salaam submitted by Mr. J. McHardy.

Mr. McHardy's species, which he believed to be *A. venustipes*, and reported as common in a localised area, shows the following differences from the Oriental form: (1) Proboscis with very few pale scales on the basal half, but with the white median and apical rings more sharply defined and broader, averaging nearly twice as long as diameter of proboscis; (2) The two little clumps of black scales on the posterior third of the scutum are suberect instead of almost decumbent; (3) Segments 2–4 of the hind tarsi are mainly black, the white scales at base and tip occupying less than one-third instead of about three-quarters of the total length of these segments; (4) The black scales on these segments are conspicuously roughened dorsally, so that in side view the hind tarsi appear thickened towards the end; (5) The fifth hind tarsal segment is entirely white, whereas in *A. venustipes* it usually has at least a few black scales at the tip beneath; (6) The scattered yellow scales on the wings are much less numerous, and the white markings therefore show up more clearly; (7) There is a white spot beyond the middle of the third longitudinal vein which is not present in *A. venustipes*.

The above distinctions, and especially those of the hind tarsi, seem to be quite sufficient to indicate the distinctness of the Dar-es-Salaam species from *A. venustipes*. From *A. africana* it is even more distinct, notably in its larger size, fewer yellow scales on scutum, presence of outstanding scales at base of hind tibiae beneath, markings of hind tarsi, and absence of a patch of yellow scales at base of wing.

As Enderlein's type *L. furfurea* has lost the last four segments of its hind tarsi, it cannot be said with certainty that it is identical with the Dar-es-Salaam species. Some points in Enderlein's description—such as the statement that the apical third of the proboscis has scattered white scales, and the omission in the description of the wing-markings of any reference to a white spot on the third vein distinct from the small one at the tip—are at variance with the material before me, but in general the description applies quite well. The species certainly occurs in West as well as in East Africa, for since the above notes were written I have examined a female specimen from Matadi, Belgian Congo, collected by Dr. Duren, which is similar in every respect to the Dar-es-Salaam specimens.

The four species of *Aëdomyia* now known may be distinguished as follows :

1. White ring at junction of first and second hind tarsal segments narrow, especially beneath; hind tibia with suberect scales at base beneath (South America) ... ... ... ... ... ... *squamipennis*, Arr.
   White ring at junction of first and second hind tarsal segments broader ... 2.
2. Hind tibia without suberect scales at base beneath ; black ring on third hind tarsal segment broad, on fourth narrow (West Africa, Uganda, Nyasaland) ... ... ... ... ... ... ... *africana*, N.-L.
   Hind tibia with suberect scales at base beneath ... ... ... ... 3.
3. Black rings on third and fourth hind tarsal segments both narrow (India to New South Wales) ... ... ... ... ... *venustipes*, Skuse.
   Black rings on third and fourth hind tarsal segments both broad (Kamerun, Dar-es-Salaam) ... ... ... ... ... *furfurea*, End.

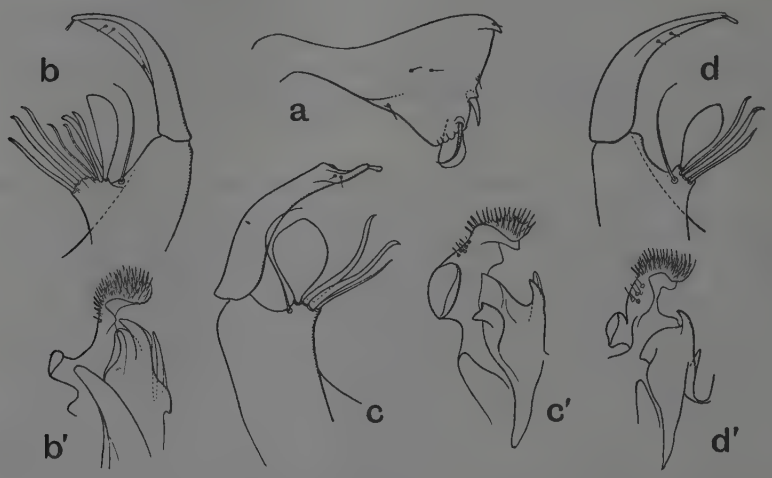



Fig. 1. Details of male hypopygia. Clasper of : *a*, *Aëdes* (*Aëdimorphus*) *phyllolabis*, sp. n. Clasper with lobe of side piece of : *b*, *Culex schwetzi*, sp. n. ; *c*, *C. pruina*, Theo. ; *d*, *C. philipi*, sp. n. Half of anal segment and aedeagus of: *b'*, *C. schwetzi* ; *c'*, *C. pruina* ; *d'*, *C. philipi*.

**Culex schwetzi,** sp. n.

*Head* with all the dorsal scales (decumbent and erect) yellowish. Antennae with basal segment yellowish, darker on lower half ; flagellar segments in ♀ (except last few) each with about 16 long hairs in the whorl, instead of the usual 6, so that the antennae in this sex appear subplumose. Palpi and proboscis dark ; palpi in ♂ longer than proboscis by scarcely more than the last segment, in ♀ about twice as long as clypeus. *Thorax* with integument mainly pale ochreous ; scutum with three broad confluent dark stripes ; sternopleura with a small brownish spot in middle. Mesonotal scales coarse and pale. Lower mesepimeral bristles varying in number from one to three ; all pleural bristles pale ; no postspiracular scales. *Abdomen* dark brown dorsally, with rather broad and complete dull white bands on tergites 4–7 or 3–7 in both sexes ; sternites with dark apical bands. Hypopygium (fig. 1 *b*) : Clasper rather broad but fairly evenly tapering towards tip. Lobe of side-piece

with the usual group of three rods, two with slightly hooked tips, but between these three and the leaf is an additional group of four rather shorter rods, two very slender, the other two stouter ; leaf rather long and narrow. Lobes of ninth tergite with a few hairs only. Basal arm of tenth sternites short, flattened, but not unusually broad. Mesosome of rather simple structure, as figured. *Legs* dark, femora pale beneath ; hind femora on outer side whitish almost to the tip ; hind tibiae entirely dark outwardly, without apical pale spot. *Wings* with narrow dark scales ; fork-cells of moderate length, upper about 2·5 times as long as its stem in ♀. Wing-length, about 4 mm.

BELGIAN CONGO : Stanleyville, x–xi.1927 (*Dr. J. Schwetz*) ; a series reared from larvae ; type ♂, paratypes 3 ♂ 6 ♀, in British Museum.

Owing to the light-coloured thorax this has much resemblance to *C. pruina*, Theo., of which it was at first thought to be a variety, especially as typical specimens of *C. pruina* were present in the same collection. A careful comparison however soon showed that *C. pruina* differed in several important respects, notably (1) in the longer male palpi, which exceed the proboscis by almost the length of the last two segments ; (2) the less hairy female antennae, which have only six hairs in the whorl on each segment ; (3) the structure of the hypopygium, especially the larger and more hairy lobes of the ninth tergite, the irregular shape of the tip of the clasper, the large subcircular leaf, and the presence of only three rods on the lobe ; (4) the longer fork-cells, the upper fork in the female being fully three times as long as its stem ; (5) the abdominal markings, the male having only tergites 5–7 banded and the female being usually without complete bands even on these segments. The hypopygium of *C. pruina* is here figured (for the first time) for comparison with *C. schwetzi* and with *C. philipi*, described below. The distinctions in the hypopygium from *C. grahami*, Theo., and *C. ingrami*, Edw., which are somewhat similar to the new species, will be apparent from a comparison of the figures (Bull. Ent. Res., v, 1916, p. 69, and vi, 1916, p. 360). Both *C. grahami* and *C. ingrami* have the mesonotal integument dark ; the form also differs from *C. schwetzi* in the longer palpi of the male.

The variation in the number of lower mesepimeral hairs tends to obliterate the distinction between the *duttoni* and *pipiens* groups of species as defined by me (Bull. Ent. Res., xiii, 1922, p. 84).

**Culex philipi,** sp. n.

*Head* with the upright scales dark brown, decumbent scales pale. Palpi and proboscis dark ; palpi in ♂ longer than proboscis by scarcely more than the length of the last segment. Antennae with basal segment light above, dark beneath ; flagellar segments in ♀ normal, with only 6 long hairs in the whorl. *Thorax* with integument mainly dark above, shoulders more or less distinctly pale, especially in ♂ ; pleurae mainly pale, but with a rather large though ill-defined brown spot above middle of sternopleura. Mesonotal scales coarse and pale. Lower mesepimeral bristles varying in number from one to three (1 in ♂, 2–3 in ♀) ; no post-spiracular scales. *Abdomen* blackish dorsally, lateral basal white spots distinct from above only on tergites 6 and 7 ; sternites with dark apical bands. Hypopygium (fig. 1, *d*) : Clasper evenly tapering and slender apically. Lobe with three rods, an oval leaf and a seta. Basal arm of tenth sternites very short and broad. Mesosome of simple structure, inner tooth very short. Lobes of ninth tergite with few hairs. *Legs* and *wings* as in *C. schwetzi*.

NIGERIA : Lagos (*C. B. Philip*), type ♂, paratypes 2 ♂, 4 ♀, reared from larvae found in crab-holes, in company with *C. cinerellus*, Edw.

This is another species belonging to the same group as *C. pruina*, from which it differs in the shorter ♂ palpi, darker thorax, and structure of hypopygium (shape of claspers, etc.). A single male was included in the British Museum series of *C. pruina*, collected by Dr. W. M. Graham at Lagos in 1909.

## III. The Larvae and Pupae of *Eretmopodites*.

The genus *Eretmopodites* is confined to tropical Africa, where seven or eight species are known. The commonest of these species, *E. chrysogaster*, has recently been shown to be capable experimentally of transmitting the virus of yellow fever and may perhaps be of some practical importance. The genus was at first placed in the Sabethine group, partly on account of the presence of postnotal bristles and partly on account of the absence of a definite ventral brush on the anal segment of the larva. Later I showed that the adults all possess post-spiracular bristles, a character in which they differ from all the genera of the Sabethine group and resemble *Aëdes* and its allies. A careful examination of the larvae also shows that they are not true Sabethines, but have more in common with *Aëdes*, as is shown for example by the following three features: (1) the prothoracic hairs are all rather small and inconspicuous, whereas in all the Sabethine larvae known to me some at least are strongly developed; (2) the siphon carries only a single pair of postero-ventral hair-tufts, whereas the Sabethines have numerous scattered siphonal tufts; (3) although the anal segment has no definite brush, there are four separate ventral hairs on each side, instead of only one as in the Sabethine group.

Up to the present only two larvae of this genus, those of *E. chrysogaster* and *E. silvestris*, have been fully described (Macfie & Ingram, Bull. Ent. Res., vi, 1923, p. 417, and Ingram & de Meillon, S. Afr. Inst. Med. Res., iv, 1927, p. 64), although some of the main points of distinction of *E. quinquevittatus* and *E. inornatus* have been mentioned by Macfie & Ingram, and by myself. During 1928 Dr. J. Schwetz reared large numbers of *Eretmopodites* at Stanleyville, Belgian Congo and presented to the British Museum material including larvae of *E. grahami*, *E. oidipodeios* and probably *E. leucopus*. The larvae of all the species, therefore, are now known, with the exception of *E. dracaenae*, and, perhaps, as noted below, of *E. leucopus*. I give herewith keys to the known larvae and pupae together with some additional notes. The most striking differences between the larvae of the various species are to be found not so much in the head, siphon and anal segment, as in the lateral hairs of the thorax and abdomen, and especially the meso- and meta-thoracic pleural hairs.

### *Larvae.*

1. Abdominal segments i–vi with conical chitinous lateral plates, the surface of which is rugose, and from which arise single stout bristles; all the main hairs of thorax single ... ... ... ... ... ... ... ... 2.
   Abdominal segments i–vi with lateral chitinous plates absent, or if present not very conspicuous and with smooth surface; some at least of the thoracic hairs double or multiple ... ... ... ... ... ... ... 3.

2. Comb-scales smaller, each with a number of strong teeth *chrysogaster*, Grah.
   Comb-scales larger, quite simple, thorn-like and sharply pointed *grahami*, Theo.

3. Mesothoracic pleural group including two long single hairs, third hair not much shorter and with 2–4 branches; pecten of 3–5 strong teeth; comb-teeth strong and pointed ... ... ... ... ... ... ... ... 4.
   Third hair of mesothoracic pleural group barely half as long as the other two and consisting of 6–15 branches; pecten of 0–2 very small inconspicuous teeth; comb-teeth weak and blunt ... ... ... ... ... ... 5.

4. Abdominal segments i–ii each with only one strong lateral hair, forked at base; siphonal index only 1 ... ... ... ... *silvestris*, Ingr. & de M.
   Abdominal segments i–ii each with two strong lateral hairs, one above the other as usual, upper forked at base; siphonal index fully 2
   ? *leucopus*, Grah.; *oidipodeios*, Grah.

5. Third mesothoracic pleural hair with 6–8 branches ; abdominal segments i–vii with a pair of strong dorsal hairs, and iii–v with a pair of strong ventral hairs in addition to the usual lateral hairs ; no distinct subsiphonal tuft *inornatus*, Newst.

Third mesothoracic pleural hair with 12–15 branches ; abdominal segments i–v with the usual lateral hairs only strongly developed ; subsiphonal tuft very stout, arising from a distinct tubercle ... *quinquevittatus*, Theo.

*Pupae.*

1. Tuft of first abdominal segment present, composed of 5–12 plumose (not dendritic) branches (fewest in *E. quinquevittatus*) ... ... ... ... 2.

Tuft of first abdominal segment absent or represented by a single hair (rarely with 2–3 branches) ... ... ... ... ... ... ... ... 5.

2. Terminal hair of paddle single ... ... ... ... ... ... 3.

Terminal hair of paddle branched ... ... ... ... ... ... 4.

3. Lateral hair of eighth segment with 6–8 branches *chrysogaster*, Grah.; *grahami*, Theo.

Lateral hair of eighth segment single ... *sp. inc.* (Sierra Leone, Bacot).

4. Terminal hair of paddle with 2–7 branches *oidipodeios*, Grah.'; *leucopus*, Grah.

Terminal hair of paddle with 10–17 branches and very large ; paddles unusually small ... ... ... ... ... ... ... *quinquevittatus*, Theo.

5. Terminal hair of paddle with 6–8 branches ; paddles longer than broad *inornatus*, Newst.

Terminal hair of paddle single ; paddles not longer than broad ... 6.

6. Terminal hair of paddle strong, as long as paddle or longer *silvestris*, Ingr. & de M.

Terminal hair of paddle fine, not half as long as paddle ... *dracaenae*, Edw.

**Eretmopodites chrysogaster,** Graham.

Of this species there are three forms differing slightly in the male hypopygium and hind tarsi : the type form and var. *semisimplicipes*, Edw., are both widely distributed in West Africa ; the var. *subsimplicipes*, Edw., seems to represent the species in East Africa.* Of the two former, abundant larval and pupal material has been received from Dr. Schwetz, collected in fallen leaves in forest in the neighbourhood of Stanleyville and the lower Lomami. Comparison of these specimens with other material in the British Museum representing all three varieties has failed to reveal any constant difference in the larvae. In an early paper (Bull. Ent. Res., iii, 1912, p. 76) I suggested that the larvae might be distinguished by the number of pecten-teeth and comb scales, but the differences noted are probably due only to individual variation. There is also some variation in the form of the comb-teeth, the median spine being sometimes more strongly developed than is shown in the figures of Macfie and Ingram.

It may be noted here that the figure of the larva given by me (Bull. Ent. Res., iii, 1912, p. 47) is inaccurate in one respect. The hair-tuft shown on the seventh abdominal segment belongs to the pupal and not to the larval integument ; in this

* Typical *E. chrysogaster* has recently been found by Mr. J. McHardy in Dar-es-Salaam, this being the first East African record. As the three forms are not geographical races it may be that they are actually distinct species. The hypopygial differences are constant and definite, but *chrysogaster* and var. *semisimplicipes* are not distinguishable in the female. Mr. McHardy has called my attention to a character by which the var. *subsimplicipes* may be distinguished in both sexes from the other two forms : the silvery spot on the lower part of the sternopleura is absent or represented by a few scales only.

species, as in all other larvae of the genus, there is no strong lateral hair on the seventh abdominal segment, all the hairs of this segment being very short and inconspicuous.

The description of the larva given by Macfie and Ingram needs supplementing in regard to the pleural hairs—those groups of hairs which, as shown by Puri (Ind. Journ. Med. Res., xvi, 1928), represent the larval legs and are of considerable importance taxonomically for specific and even generic differentiation. The *prothoracic* group is ventral rather than lateral in position and includes four hairs not always easy to distinguish. One of these is of moderate length but very slender and single; two more are about half the length of the first, one of them sometimes double; the fourth is extremely small and split into several branches. The *mesothoracic* group is situated low down on the side of the thorax and includes only three hairs, which are all of equal length, stout, single, and slightly feathered, twice as long as the longest hair of the prothoracic group. The small chitinous plate from which these hairs arise does not carry a spine. The *metathoracic* group also includes only three hairs; two of these are long, stout and single like those of the mesothoracic group, the third slender and barely one-third as long as the other two. The chitinous plate from which these hairs arise is similar to that of the mesothoracic group and is more or less connected with the smaller plate at the base of the dorso-lateral hair. The meso- and metathoracic pleural hairs are clearly shown in the figure given by Macfie and Ingram.

**Eretmopodites grahami,** Theo.

I have elsewhere suggested that this should be regarded as another variety of *E. chrysogaster*. There is, however, a definite distinction in the larvae. Specimens sent by Dr. Schwetz all have all the comb-scales thorn-like, without any lateral teeth, and rather larger than in *E. chrysogaster*. In other respects the larvae of *E. grahami* closely resemble those of *E. chrysogaster*, the chaetotaxy of the head, thorax and abdomen being the same. The pupa does not differ from that of *E. chrysogaster*.

**Eretmopodites silvestris,** Ingram & de Meillon.

This larva differs from all the others in having only one strongly developed lateral hair on abdominal segments i–ii, as on iii–iv. The thoracic pleural hairs are similar to those of *E. chrysogaster* except that one of the long hairs in the meso- and metathoracic groups is double.

**Eretmopodites oidipodeios,** Graham.

*Larva.* Resembles that of *E. chrysogaster*, differing chiefly as follows.—Mentum more regularly triangular; about nine teeth on each side of a small central tooth, increasing in size towards base of plate. Third mesothoracic pleural hair only about two-thirds as long as the others and composed of 2–4 branches. One of the two long metathoracic hairs in some specimens double. Lateral plates of abdominal segments i–vi smaller, less conically produced, and quite smooth; lateral hairs not so stout, the upper one on segments i–ii forked close to base. Comb consisting of 2–6 long, sharp-pointed teeth, placed in a more or less regular row and finely fringed at base only. Siphon somewhat longer, index 2–2·5.

*Pupa.* Resembles that of *E. chrysogaster*, differing as follows.—Dorsal hairs of abdomen, especially on segments i–iii, somewhat shorter and more slender; on segment iii the outer pair of long hairs shorter than the inner (in *E. chrysogaster* the four hairs are of the same length). Lateral hairs of segments vii and viii smaller and composed of fewer branches (6–8), that on segment viii distinctly shorter than the paddle. Paddles not emarginate apically (as they are in *E. chrysogaster*); midrib strong and distinct, of even width to end of paddle (in *E. chrysogaster* it is narrowed and faint apically); apical hair divided almost to the base into 2–4 branches.

**Eretmopodites leucopus,** Graham.

A few specimens of this species were reared by Dr. Schwetz from larvae or pupae found in fallen leaves in forest in company with either *E. chrysogaster*, *E. grahami*, or *E. oidipodeios*. In one case *E. leucopus* alone was reared; unfortunately the larval skin was not kept, but the pupal skin is quite similar to that of *E. oidipodeios*, and the whole larvae from the same leaf also show no distinguishing features. It is, therefore, uncertain to which of these two species the larvae belong. As the two are certainly nearly allied, it is possible that the early stages may not obviously differ.

**Eretmopodites inornatus,** Newst.

*Larva.* Mentum with about five teeth on each side of the trifid median tooth, outermost tooth larger than the others. Prothoracic pleural hairs even less conspicuous than in *E. chrysogaster*. Mesothoracic pleural hairs comprising two long single hairs as in the other species, but the third hair split to the base into 6–8 branches of variable length, longest branch not quite half as long as the two long hairs. Metathoracic group including two very long stout hairs (one sometimes double), third hair very short and slender. Chitinous plates of both meso- and metathoracic pleural groups both large, produced posteriorly into a distinct spine. Lateral hairs of meso- and metathorax (immediately above the pleural hairs) single as in most other species. Abdomen with more strongly developed chaetotaxy than in the other species, segments i–vi having each a pair of subdorsal single hairs, almost as long and strong as the lateral hairs; segments iii–v a pair of similar but rather shorter subventral hairs; segment i a pair of short, stout ventral hairs; and segment vii a pair of dorso-lateral hairs of moderate length. Lateral hairs all single, no distinct chitinous plate at their base; as usual segments i and ii have each two lateral hairs, one above the other. Comb of about 20–30 scales, broadly rounded apically with a very short and indistinct apical fringe. All hair-tufts of eighth segment, including subsiphonal tuft, very minute and inconspicuous. Siphon either without pecten or with 1–2 very small teeth near base; tuft two-branched; index about 1·5. Anal saddle with posterior margin smooth; gills barely twice as long as saddle.

*Pupa.* Dorsal hairs of basal abdominal segments much shorter than in *E. chrysogaster*. Dendritic tuft of first segment represented by a strong hair, which is either single or split apically into 2–3 branches. Respiratory trumpets shorter and with larger opening than in *E. chrysogaster*, resembling those of *E. quinquevittatus*. Lateral tuft of eighth segment slightly longer than paddles, which are not quite so small as in *E. quinquevittatus*; midrib not darkened; paddle-tuft 4–6-branched.

Described from several specimens from Lagos, collected by Dr. A. C. Connal in 1910.

**Eretmopodites quinquevittatus,** Theo.

The main distinctions between this larva and that of *E. inornatus* have been mentioned in the key. In addition it may be noted that the larva of *E. quinquevittatus* has the lateral hairs of the meso- and metathorax (those immediately above the pleural hairs) each split into 4–6 branches; the two longer mesothoracic pleural hairs are also 2–3-branched; the lateral abdominal hairs are more slender, and the upper lateral hair of segments i and ii is shorter than the lower, whereas in *E. inornatus* the reverse is the case.

Macfie & Ingram, in their description of the larva of this species state that "the dorso-lateral setae on the middle third of the thorax" form "a large tuft, half of which is composed of short and half of long hairs." This remark applies not to the dorso-lateral hair-tuft but to the pleural hairs.

## IV. The Larva and Pupa of *Mimomyia plumosa*, Theo.

Larvae and pupae of this species were obtained by Dr. A. Ingram at Bole, Gold Coast, in 1912, and at Sunyani, Ashanti, in 1915, but by some oversight they were never described. The larvae, however, are of special interest on account of the remarkable structure of the head, which is very different from that of any other species of the genus, or indeed of any other Culicine mosquito. *M. plumosa* is the type of Theobald's genus *Megaculex*, and if we admit larval characters for generic definition without reference to the adult, the genera *Mimomyia* and *Megaculex* would certainly need separation. But in the adult stage the closest examination fails to show any important difference between *M. plumosa* and *M. mimomyiaformis* except in size and in minor details of ornamentation, although the larva of *M. mimomyiaformis* is in no way abnormal. *Megaculex*, therefore, cannot be regarded as more than a subgenus of *Mimomyia*.

*M. plumosa* is much larger than any of the other species of the genus, and it may be that the peculiar modification of the larvae is in some way connected with increase in size. It is perhaps worth noting that predacity in mosquito larvae seems usually to lead to increase in size, as in the genera *Megarhinus*, *Psorophora*, *Mucidus*, *Lutzia* and *Goeldia*. Whether *M. plumosa* is a predacious form of *Mimomyia* cannot at present be stated; there is little in the structure of the mouth-parts to suggest that this may be the case. I describe Dr. Ingram's material below.

### *Larva* (fig. 2).

*Head* rather small, of very unusual shape, largely on account of the conspicuous angular indentation of the lateral margin (as seen from above or below) immediately in front of the eye. Clypeal spines slender, short, bristle-like, not spine-like as in other species of the genus. Dorsal hairs all short, the longest barely half as long as head; *A*, *B* and *C* each with 6 or more branches; *d* single, placed far forward, and very little shorter than the others. Ventral lateral hair also short and inconspicuous, 2–3-branched. Mouth-brushes very short and composed of rather few hairs. *Antennae* short (not much over half as long as head), sparsely spicular towards base only; tuft small, 2–3-branched, placed well before middle of main portion of shaft; subapical bristles short (barely twice as long as diameter of shaft); portion of antenna beyond subapical bristles stouter than usual, and definitely articulated with shaft, forming a second segment; apical bristles very small. *Mentum* apparently absent, or at least with its posterior margin quite devoid of teeth and very little prominent, a unique feature among mosquito larvae. *Mandibles* also without blackened teeth. Maxillae short and broad, without the conspicuous apical spine characteristic of most species of this genus. *Thorax* broad; hair-tufts plumose as usual, but short, longest lateral tufts barely half as long as diameter of thorax. (The specimens are somewhat damaged, and a full description of the thoracic chaetotaxy cannot be given.) Meso- and metathoracic pleural hairs as in other species of the genus set in large chitinous plates which have each a conspicuous spine; mesothoracic group with two long single hairs and a 6–8 branched tuft; metathoracic with one long single hair and a similar tuft. *Abdomen* with two conspicuous lateral hairs on segments i and ii, upper 4–6-branched, lower double; lateral hairs of following segments shorter. Comb consisting of about 7 thorn-like scales in a single irregular row; siphonal and subsiphonal tufts large. Siphon of normal structure, index about 3·5; acus small; tuft of about 7 branches slightly beyond middle; pecten of 2–4 well-developed spines. Anal segment with posterior margin of plate very finely spinulose; upper dorsal hair 10-branched, lower 3-branched. Gills somewhat longer than anal segment.

### *Pupa* (fig. 2, *c*).

Respiratory trumpets long, but stouter than in the other species; almost the apical half whitish; opening large and somewhat expanded, with a slit-like prolonga-

tion for some distance towards base. Paddles as figured by Ingram & Macfie for *M. mimomyiaformis*, but with two semicircular white spots, one on inner margin.

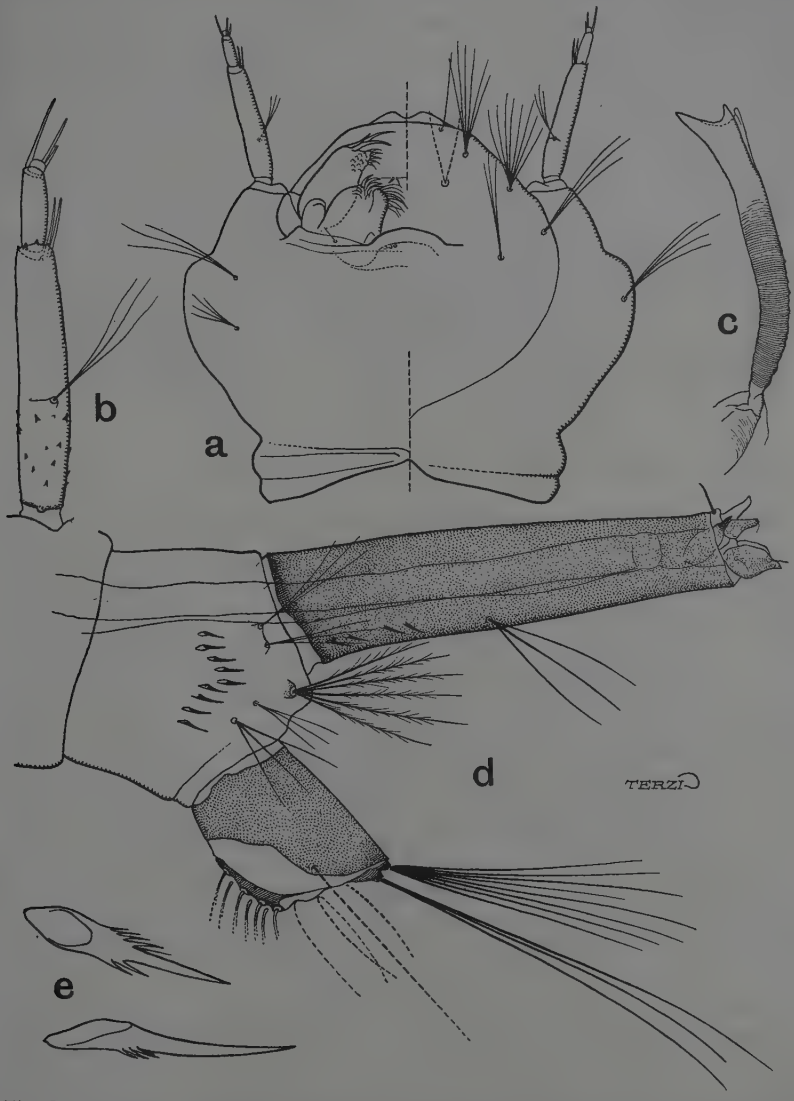



Fig. 2. Larva of *Mimomyia plumosa*, Theo.: *a*, head from below (on left) and from above (on right) (clypeal spines accidentally omitted); *b*, antenna, further enlarged; *d*, tip of abdomen, from side; *e*, comb teeth. Pupal respiratory trumpet shown at *c*.

## V. The Larva and Pupa of *Culex moucheti*, Evans.

At the end of 1927 I received from Dr. Schwetz some very peculiar Culicine larvae taken from a hole in a fallen papaya tree at Simi-Simi, Stanleyville, in October, 1927.

Adults received under the same number were *Culex moucheti*, Evans, but the larvae were so very unlike any known *Culex* that I was unable to believe they could belong to that genus, and even suggested to Dr. Schwetz that they might belong to some genus of mosquitos hitherto unknown in Africa. However, at my request Dr. Schwetz obtained fresh material under similar circumstances and at the same locality in May, 1928, and as before reared a series of *Culex moucheti* adults. There might still have been an element of doubt as to whether the larvae and pupae belonged to this species, as no isolations were made, but fortunately among the material collected I found one or two male pupae ready for emergence and one or two larvae ready for pupation. By dissecting out the male hypopygium and by observing the hairs of the pupal abdomen under the larval skin it was possible to establish beyond any question the identity of the larva and pupa described below with *C. moucheti*.

In view of the many remarkable features of the larva it might have been expected that some peculiarities would also be found in the adult, but this is not the case. Males and females of *C. moucheti* are closely similar to other species of the *decens* group (such as *C. guiarti*, Blanch., *C. grahami*, Theo., etc.) except in details of hypopygial structure ; the only feature which distinguishes the species rather sharply from other members of the group is the colour of the basal segment of the antenna, which is bright orange instead of brown or black.

*Larva* (figs. 3, 4 *d*, 4*e*).

Length (full-grown) about 8 mm. ; pale in colour, no markings on head, siphon not very dark.

*Head* of moderate size, two-thirds width of thorax, and not much broader than long. Clypeal spines slender and bristle-like. Hairs *A*, *B* and *C* all placed near level of insertion of antennae, erect or curved backwards, not projecting forwards as usual in *Culex*, and all short, with branches simple; *A* 4–5-branched from base, *B* and *C* 2–3-branched at a short distance from base ; *B* almost in line with *A* and *C* ; distance between hairs *C* four times that between *B* and *C* ; *d* very minute and placed far forward ; *e* small and 2–3-branched ; lateral hair opposite *e* almost as large as *B* or *C*, 5–7-branched. *Antennae* very short, hardly more than one-quarter as long as head, cylindrical on basal half, then slightly tapering ; shaft without spicules ; a small 4–5-haired tuft on dorsal surface well before middle, hairs in tuft less than twice as long as diameter of antennae ; four short and equal apical bristles and a stout papilla. *Mentum* of the usual shape, with about 7 large and equal teeth on each side of median tooth. *Mandibles* and *maxillae* resembling those of other species of *Culex* ; mouth-brushes short, but hairs very numerous and unmodified. *Thorax :* Dorsal hairs of prothorax numerous and moderately long, longest just reaching front margin of head ; near middle of front margin is a pair of conspicuous chitinous plates, each of which includes bases of three hairs, one triple, the other two double ; outside these plates are four hairs on each side which have respectively 3, 2, 1 and 4–5 branches. Mesothorax with one fine single hair dorsally towards each side ; lateral tufts large, but somewhat shorter than diameter of thorax, of 6–8 plumose branches. Metathorax bare above, lateral tufts similar to those of mesothorax. *Pleural hairs :* Prothoracic ventrally placed, one moderately long and single, two short and single, one minute and branched ; mesothoracic : two long, stout, single and subplumose, one forming a large tuft of about 8 plumose branches, not much shorter than the single hairs, the fourth absent ; metathoracic : two very long and stout, one single, the other double ; third short, slender and single, fourth absent. Both meso- and metathoracic groups set in distinct chitinous plates, posterior margin of which is produced and dentate. *Abdomen :* First segment with two lateral hairs only, dorsal 3–4-branched, ventral single or double and about as long as diameter of abdomen. Second segment also with lateral hairs only, but dorsal and ventral both 4–5-branched and somewhat longer than those of first segment. Third segment with lateral hairs similar to those

of second, but in addition with conspicuous pairs of dorsal and ventral hairs, forwardly directed and each 4–5-branched. Fourth segment with only one distinct lateral 3-branched hair (dorsal lateral hair minute) and pairs of fine, single dorsal and ventral hairs. Fifth and sixth segments with lateral hairs very much shorter than on preceding segments, only about one-third as long as diameter of abdomen; hairs on seventh segment still shorter. Eighth segment with a large sub-siphonal tuft of 7–8 stout

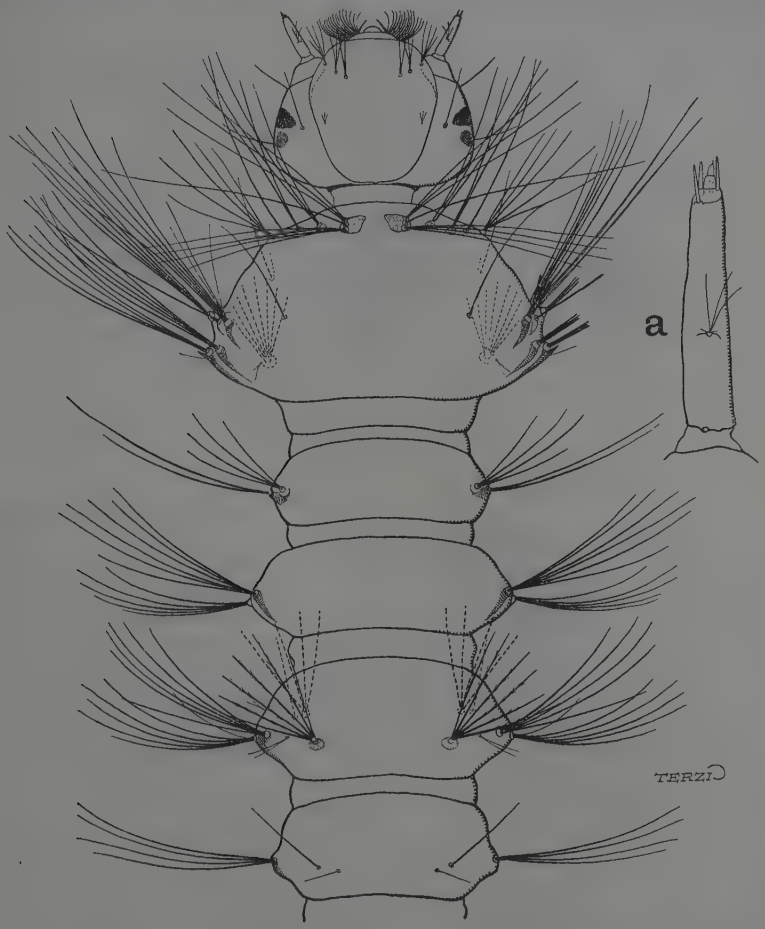



Fig. 3. Larva of *Culex moucheti*, Evans, head, thorax, and first four abdominal segments, from above; *a*, antenna further enlarged.

branches, and a pair of ventrilateral hairs, ventrally directed and 2–3-branched, branches lying very close together; the other three tufts present, but very minute. *Comb* represented by only two or occasionally three rounded scales with fine apical fringe. *Siphon* very small, cylindrical, index only about 1·2; acus well developed. No trace of pecten. Only two pairs of hair-tufts, one near base, the other near middle and more ventrally placed; both minute, not a quarter as long as diameter of siphon,

5–6-branched. Valves rather large, but of normal form. *Anal segment* with a rather small saddle reaching only half-way down sides, its margins smooth. Outer dorsal hair single, inner 6-branched. Lateral hair of saddle large, 5–6-branched, somewhat longer than anal segment. No trace whatever of ventral brush or barred area. Gills very stout, sausage-shaped, variable in length and thickness, usually 4–5 times length of saddle and about half diameter of anal segment, dorsal and ventral pairs subequal and rounded apically.

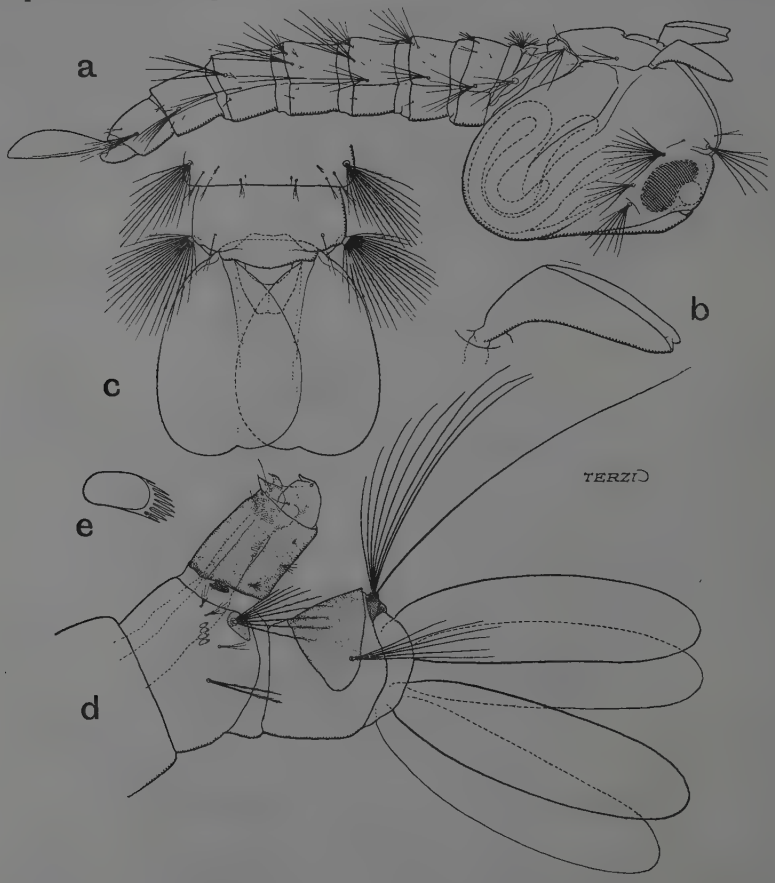



Fig. 4. *Culex moucheti*, Evans: *a*, pupa side view; *b*, respiratory trumpet of pupa; *c*, tip of abdomen of pupa, from above; *d*, tip of abdomen of larva, showing complete absence of anal brush; *e*, comb-scale further enlarged.

*Pupa* (fig. 4, *a–c*).

Length (extended) about 7 mm.; pale in colour, integument darkened only in region of metathorax and base of abdomen.

*Cephalothorax.* Respiratory trumpets of moderate size, stout; opening remarkably large, extending to nearly three-quarters of total length of trumpet; margins of

opening finely crenulate. Near front margin of cephalothorax on each side is a series of four very large tufts, each consisting of about 10 subplumose branches, the third tuft from above somewhat smaller than the others; upper two tufts apparently near front margin of prothorax, lower two on head at base of sheaths of mouth-parts. Three small tufts immediately behind the large upper prothoracic tuft. A moderately large 3-branched tuft some distance behind respiratory trumpet. Metanotum with large lateral tufts having at least 12 branches. *Abdomen:* Lateral tufts on segments i–vi large, 3–5-branched; on vii and viii somewhat shorter, but with 12–16 branches. Sublateral tufts on segment ii small, double; on iii rather longer, double; on iv–vi much longer, with 3–5 stout sub-plumose branches; on vii and viii minute. Submedian tufts on segment ii dendritic in form; on iii and iv large, with 10–12 simple branches; on v and vi moderately large, with 5–6 branches; on vii and viii minute. *Paddles* large, deeply emarginate at tip of midrib, devoid of fringe and of apical hair.

The most astonishing feature of this larva is the total absence of the anal brush, which is not even represented by the single pair of hairs or hair-tufts which occur in all the true Sabethine genera. Further remarkable peculiarities are the form of the clypeal hairs; the presence of conspicuous dorsal and ventral tufts only on the third segment of the abdomen (there are numerous specimens in perfect condition, all showing this character); the reduction of the comb and absence of the pecten, and the form of the gills; also the large anterior tufts of the pupa.

Several mounted larvae show numerous broken hairs in the gut, suggesting that they have fed upon other mosquito larvae; but as the mouth-parts do not seem to be in any way modified, the predacious habit may not be normal.

## VI. New Species Collected by Mr. R. W. Paine in Fiji.

**Rachionotomyia rotumana,** sp. n.

*Head* mostly black-scaled; a narrow whitish orbital line, appearing bluish when viewed from in front. Vertical and orbital bristles black, not widely separated. Proboscis dark, long and slender, about one-fourth longer than the abdomen. Palpi dark, in ♂ rather over two-thirds as long as the proboscis, in ♀ exceeding the bare clypeus by rather more than its length. Antennae in ♂ plumose, extending to end of penultimate segment of palpi. *Thorax* with integument dark brown, except for a broad paler stripe on pleurae. Mesonotal scales small, narrow, dark brown except for a narrow border of white ones. Scutellar scales small, flat, dark brown, not completely covering scutellum. Anterior and posterior pronotal scales white; a broad stripe of flat white scales covering the pale pleural stripe; also a few white scales on lower part of sternopleura immediately in front of middle coxa. Several pairs of dorso-central bristles (mostly broken off in the material available). One anterior pronotal bristle; one or two dark spiraculars; one dark upper sternopleural, placed just above the white stripe; no lower sternopleurals; a few pale upper mesepimerals. *Abdomen* dark brown above, creamy-white below; tergites 3–7 each with lateral basal creamy spots, which are larger and just visible dorsally on the last few tergites. Hypopygium of the type usual in the genus; lobes of ninth tergite about as long as broad, square-ended, each with about six bristles in a close-set row at the tip; clasper long, curved, very slender and tapering; basal lobe with about three long stout bristles. *Legs* dark, except under sides of femora. Hind tarsi with two very small claws. Larger claw of front legs of ♂ with a blunt median tooth, of middle legs simple. *Wings* dark-scaled; outstanding scales linear. Upper fork-cell not quite twice as long as its stem, its base slightly proximal to that of the lower. Wing-length barely 3 mm.

*Pupa* closely resembling that of *R. caledonica* as figured by Buxton (Researches in Polynesia and Melanesia, p. 75); the shape of the paddle in the four specimens

examined somewhat intermediate between that of the two examples of *R. caledonica* shown in Buxton's figures.

*Larva* similar to that of *R. caledonica* as described and figured by Buxton, differing chiefly as follows: Clypeal spines less stout. Antennae somewhat longer, fully six times as long as their greatest breadth. Bristles in tuft at tip of maxilla much less stout. Metathoracic spines very inconspicuous and bristle-like, fully half as long as and very little thicker than the hairs in the large thoracic tufts; the two "spines" subequal in length (in *R. caledonica* one is much shorter than the other). Siphon shorter (index about 2), with rather fewer postero-ventral hair-tufts (about 10 instead of 13–16).

As in *R. caledonica* the maxilla is broad and flat, with a row of 10–12 longish teeth on its inner margin, and a tuft of about a dozen bristles at its tip; there is no spine on the mesothorax, this being represented by a long slender hair; there are four distinct stellate tufts on the dorsum of each abdominal segment; the eighth segment has a close-set comb but no chitinous plate.

Fiji: Rotuma I. (*Dr. W. D. Carew*); a number of larvae collected in April, 1928, and sent to R. W. Paine; adults of both sexes reared in Suva. 2 ♂ (including type), 5 ♀, presented to the British Museum by Dr. P. A. Buxton.

This new species needs comparison only with *R. caledonica*, Edw. (New Caledonia and New Hebrides) which has hitherto occupied a rather isolated position in the genus. In its adult characters *R. rotumana* is very similar to *R. caledonica*, differing chiefly in the basally, instead of apically, placed markings of the abdominal tergites, also in the absence of lower sternopleural bristles.

**Aëdes variegatus** (Dol.).

Specimens from Rotuma Island, Fiji (*Dr. W. D. Carew*), resemble the usual Fijian and Samoan form (var. *pseudoscutellaris*, Theo.) in colouring, and also in the basal lobe of the side-piece of the hypopygium, but the side-piece itself is less elongate and the clasper is relatively stout, quite as much so as in the var. *hebrideus*, Edw.

**Culex albinervis,** sp. n.

*Head* dark, clothed mainly with dark brown scales, the small narrow scales paler. Proboscis dark, with a narrow creamy white ring in middle. Palpi of ♂ of the normal form; penultimate segment narrowly pale at base and tip, clothed with dark hairs; terminal segment entirely yellowish, clothed with white hair, except for the terminal bristly hair which is black. Palpi of ♀ entirely dark, about one-fifth as long as the proboscis. *Thorax* with integument mainly dark brown, including scutum, pronotal lobes (anterior and posterior) and area behind prothoracic spiracle; most of pleurae, including sternopleura, meron and mesepimeron, pale and unmarked. Mesonotal scales very small, except for a group of long erect scales some distance in front of the wing root; in most specimens (including type) the scales are dark brown, with very slight and indistinct mottling of lighter brown, but in two females the scales on the anterior two-thirds of the scutum are entirely pure white. Pleurae almost devoid of scales; two very small patches on posterior margin of sternopleura and a very few in middle of mesepimera. Lower mesepimeral bristle absent as usual in this group. *Abdomen* dark brown above, segments 2–8 with narrow creamy basal bands, 7–8 sometimes with narrow apical pale bands in addition. Sternites largely dark in the middle, pale basally and apically. Hypopygium, side-piece not at all swollen, with a rather dense patch of pubescence adjacent to lobe; lobe small, very little prominent, undivided, with three rather stout rods (one less stout and slightly hooked at tip) and a small leaf. Tenth sternites with small basal arm. Two mesosomal plates, one small, the other large, rounded dorsally, without retrorse spine. *Legs*

dark brown, without mottling of pale scales; tarsi with creamy rings which are most conspicuous on segments 2–4 of the hind tarsi and almost entirely basal in position, only very narrowly involving the apices of the segments. *Wings* with the membrane slightly smoky, leaving small clear areas at base of *Rs* and surrounding the cross-veins, the latter white in colour and rather closely approximated; a small extent of vein $Cu_1$ adjacent to the posterior cross-vein is also whitened and devoid of scales. All scales dark brown, outstanding ones linear. Bases of forks almost level; in ♀ upper fork over twice as long as its stem. Wing-length, 3·5–4·5 mm.

*Pupa.* Trumpet narrow on the basal third, then rapidly and evenly widening to the tip; ratio of opening to total length about 3 : 7; narrow basal part dark brown, tip also somewhat darkened. Sublateral hairs of abdomen double, somewhat plumose; apical lateral tuft of eighth segment small with 6–8 plumose branches. Paddles rounded, without fringe, apical seta not distinguishable in the available material.

*Larva.* Head rather small and pale, without definite markings. Antennae moderately long and slender, curved and evenly tapering; tuft of about 15 branches placed only a little beyond the middle; shaft quite smooth and devoid of spicules; preapical bristles only a short distance before tip; most of the shaft beyond the tuft blackened. Mentum triangular, margins very finely serrate with at least 30–40 blunt denticles on each side, four or five denticles on each side of the larger median tooth somewhat more distinct than the others. Hair A with 5–6 branches; B single or double, very long and plumose; C double, shorter than B and placed obliquely behind it. Comb of about 20 sharply pointed and coarsely fringed scales. Siphon slender, tapering, index about 8; apparently only two pairs of small, two-haired ventral tufts situate beyond mid-length. Pecten with about 12 teeth, the last few widely spaced, last tooth at about one-fourth length of siphon. Anal segment ringed as usual, hind margin of plate smooth. Gills pointed, rather under twice as long as anal segment.

FIJI: Suva, 31.i.28, 2 ♂, 6 ♀ (including type ♂), reared from larvae (*R. W. Paine*).

Though a typical member of the *bitaeniorhynchus* group as defined by me, this new species is very distinct from all the other members of the group by the white cross-veins with a clear spot in the membrane surrounding them. The dimorphism in the colour of the mesonotal scales is very remarkable, but there can be no doubt that all the specimens belong to one species as they are alike in all other respects. In all the other species the cross-veins are dark as usual and the wing-membrane uniformly clear. The larva somewhat resembles that of *C. bitaeniorhynchus*, especially in the form of the mentum.

The collector sends the following interesting account of the circumstances under which the material of this new *Culex* was obtained: "On each side of the coast road from Suva where it passes some native houses bordering the Lami estate, is a ditch, which contains stagnant water pools some 20 or 30 yards in extent after rain. In dry weather there is little or no water in these ditches.

"The ditch on the shore side of the road has communication at highest tide with the sea water; and that the water accumulated after heavy rain in this ditch is brackish is evidenced by the complete lack of green algae and other characteristic fresh water plants, which thrive in the ditch on the other side of the road where the water is entirely fresh. Moreover the water taken from the shore-side ditch smelt distinctly salt, but was too foul, with house refuse and horse dung, to permit tasting. This ditch was fully exposed to the sun, and had deposits of decayed leaves at the bottom of the shallow pools.

"*Culex* eggs, larvae of all size, and pupae were in very large numbers in one pool, but were absent in another pool on the same side of the road, separated from the former by a dirt track leading to a house across the ditch. A large number of these

larvae were taken and adults bred out. Also some egg rafts were taken. It was thought at first that all the mosquitos in this ditch were *Culex sitiens* : but, although the vast majority were that species, a few *C. annulirostris* were bred out. These adults were checked with the key and descriptions given in F. W. Edwards' ' Synopsis of Adult Mosquitos of the Australian Region, 1923.' The egg rafts taken from this pool were all narrower and rather longer than those usually made by *C. fatigans*. Some of these were preserved unhatched, whilst from others larvae of *C. sitiens* were bred. The eggs seem to agree in size with those of *C. annulirostris* described by Buxton and Hopkins, 1927.

" The fresh water ditch on the landward side of the road was also examined. This was full of filamentous green algae and other water plants, and clumps of sedges at intervals caused a certain amount of shading from the sun. The collection of larvae and pupae here was made difficult by the matted lumps of green algal filaments. It was thought that *C. annulirostris* alone would be found here. There were only a few larvae and pupae in this ditch, and no egg masses were found. Some 20 larvae and pupae were collected, and amongst these were a few 4th stage larvae with exceptionally long siphons, and this appeared to be a new species. Furthermore these larvae had been feeding on green algae and their colour varied from bright green to a dull brown. The same colour variations were noticeable in the pupae, and the bright green pupae were striking objects. The pupae were quite exceptionally active. Microscopic examination of this collection revealed the fact that the 4th stage larvae and pupae belonged to a species of *Culex* not hitherto found in Fiji and not identical with any of the *Culex* larvae figured by Buxton and Hopkins from the New Hebrides. The smaller larvae resembled typical *C. annulirostris*.

" Two of the larger larvae (one bright green, the other brown) were kept separate and bred out to adults, a female with the anterior two-thirds of the scutum clothed with whitish scales, and a male with the few pale scales on the scutum. It is not known which sex came from which larva, but the latter were structurally identical as far as could be seen by preliminary microscopic inspection. Presumably these two forms belong to one species, the ornamentation of the thorax being variable.

" The same ditch was revisited for further samples on the following day ; and the lack of rain had caused the water level to fall considerably so that there was little remaining in the ditch but a scum of moist algae. Some pupae were collected from this, but no further larvae were found."

Adults reared from these pupae included one female *C. sitiens*, Wied., and one female *C. annulirostris*, Skuse, in addition to further examples of the new species. Mr. Paine points out that the pupae of these three species can be distinguished by the ratio of the length of the trumpet opening to the total length of the trumpet, which is respectively 3 : 7, 1 : 4 and 2 : 5.

## VII. The Forms Referred to the Subgenus *Skusea* of *Aëdes*.

In previous papers I have variously defined the subgenus *Skusea*, using the name at first as a convenient designation for those species of *Aëdes* without special ornamentation and with simple claws in the female sex. Later, recognising that this definition led to an unnatural grouping of species, I proposed to transfer to the subgenus *Aëdes* those species with short male palpi and narrow scales on the scutellum, leaving in *Skusea* only those with broad flat scales on the scutellum and simple claws in the female, but with either long or short palpi in the male. *Skusea* as so defined was still obviously an unnatural group and was maintained for convenience only. Further information on the early stages of some of the species, together with the discovery of new forms, now enables us to give more precise characters for the

definition of this and related subgenera. The following groups of species have at one time or another been included in the subgenus *Skusea* :—

(1) *A. pembaensis*, Theo. (East Africa), the genotype, and the closely related, or perhaps identical, *A. cartroni*, Ventr. (Madagascar). These breed in crab-holes and are characterised thus : Proboscis as long as front femora or slightly longer. Palpi of ♂ as long as proboscis, last segment short and bent downwards. Plumes of ♂ antennae not evenly spread round the segments (as in the subgenus *Aëdes*), but most of the hairs extending either dorsally or ventrally (as in the subgenera *Ochlerotatus*, *Finlaya*, and *Aëdimorphus*). Lower mesepimeral bristles present in ♀ but absent in ♂. Hypopygium very peculiar : Side-piece with subapical lobe bearing a row of strong bristles ; clasper small, with subterminal spine ; ninth tergite greatly reduced and without hairs ; anal segment small, conical, bare ; mesosome a simple tube shaped somewhat as in *Anopheles*. Female cerci short, broad, and always hidden. Claws of ♂ toothed. Larva : Antennae smooth with branched hair; clypeal hairs *B* placed almost directly in front of *C* ; siphon without acus ; pecten without detached teeth.

(2) The two Malayan species *A. furvus*, Edw. (*Stegomyia fusca*, Leic.), and *A. fumidus*, Edw., with which is perhaps to be associated the Philippine *A. amesi*, Ludl. These breed in tree-holes or leaf-bases of palms and are characterised thus : Proboscis about as long as front femora. Palpi of ♂ as long as proboscis or slightly longer, straight, slender and bare. Plumes of ♂ antennae as in the genotype. Lower mesepimeral bristles and hairs absent in both sexes. Hypopygium : Side piece with complicated sub-basal lobes ; clasper scaly and with long terminal spine ; ninth tergite very small ; anal segment with well developed tenth sternites ; mesosome apparently simple. Female cerci broadish but exserted. Claws of ♂ simple. Larva : Antenna with short, simple hair, otherwise much like that of *A. pembaensis*.

These species may be retained in the subgenus *Skusea*, at least for the present.

(3) The Indian *A. micropterus*, Giles, *A. reginae*, Edw., *A. punctipes*, Edw., *A iyengari*, Edw., *A. punctissimus*, Barr., and *A. periskeletus*, Giles. So far as known, these breed in tree-holes or bamboos and exhibit the following characters : Proboscis not longer than front femora. Palpi of ♂ as long as proboscis, last segment short and turned downwards. Antennae of ♂ as in *A. pembaensis*. Mesonotal bristles very strong. One or two lower mesepimeral bristles present in both sexes (except in *A. periskeletus*). Hypopygium : Side piece without definite lobes ; clasper with stout terminal or subterminal spine ; ninth tergite small ; mesosome divided into lateral plates bearing teeth ; anal segment with tenth sternites well developed. Female cerci short and rather broad. Claws of ♂ toothed. Larva undescribed.

The species of this group differ from all the others in having a pair of patches of whitish scales on the dorsal surface of the head, in this respect resembling the majority of species of the subgenera *Aëdimorphus* and *Stegomyia*. They are apparently more nearly related to *Aëdimorphus* than to *Skusea*, but cannot be included in that subgenus on account of the simple female claws, terminal spine of male clasper, etc. I suggest the name **Dendroskusea,** subgen. nov., with type *micropterus*, Giles.

(4) The Austro-Malayan *A. fimbripes*, Edw., *A. tonsus*, Edw., and *A. longiforceps*, Edw. These breed in crab-holes and are characterised thus : Proboscis somewhat longer than front femora. Palpi of ♂ about a quarter as long as proboscis. Plumes of ♂ antennae not very dense and more evenly spread than in the last three groups. Lower part of mesepimeron without bristles towards anterior margin, but with some fine hairs towards posterior margin. Hypopygium : Side-pieces long, with more or less developed sub-basal lobe ; clasper long, bare, with long terminal spine ; ninth tergite small, bilobed, lobes hairy apically ; mesosome simple, scoop-shaped, as in *Ochlerotatus*. Female cerci long and prominent. Male with anterior claws toothed. Larva undescribed.

These species are, perhaps, more nearly allied to the subgenera *Ochlerotatus* and *Pseudoskusea* than to *Aëdes* or *Skusea*. I suggest the name **Geoskusea,** subgen. nov., with type *fimbripes*, Edw.

(5) *A. simplex*, Theo. (India and Ceylon), *A. cancricomes*, Edw. (Andaman Is.), *A. curtipes*, Edw. (Malayan region), and probably *A. miachaetessa*, Dyar & Shannon (Philippine Is.). These breed either in crab-holes or pot-holes in mangrove swamps, and have the following characters in common: Proboscis about as long as front femora. Palpi of both sexes very short. Plumes of ♂ antennae rather evenly spread (reduced in *A. cancricomes*). One or two strong bristles present in both sexes towards anterior margin of lower part of mesepimeron. Hypopygium small: Side-pieces short, with a subapical group of strong spines and leaf-like plates; clasper very small, without articulated spine; mesosome divided, with one or two spines externally on each lobe. Female cerci short. Male claws simple. Larva: Antennae spicular, with branched hair-tuft; clypeal hairs *A*, *B* and *C* in a slightly curved line; siphon with acus; pecten with the teeth rather widely spaced.

These species have most in common with the subgenus *Aëdes* and might perhaps be placed therein, but in view of the very peculiar hypopygium it may be preferable to separate them. I suggest the name **Cancraëdes,** subgen. nov., with type *cancricomes*, Edw.

(6) *A. longirostris*, Leic., a species distributed from the Andaman Is. to Northern Australia and breeding in crab-holes and pools in mangrove swamps. Characters: Proboscis long and slender, as long as whole body and distinctly longer than front femora. Palpi very short in both sexes, hardly longer than clypeus. Plumes of ♂ antennae rather evenly spread. Lower mesepimeral bristles absent. Hypopygium peculiar: Side-piece with large basal process and well-developed apical lobe; clasper with thick terminal spine; tenth sternites with groups of small bristles subapically; mesosome simple, smooth. Female cerci long. Male claws simple. Legs unusually long, first segment of hind tarsi as long as tibia or even slightly longer. Larva: Antennae spicular, with branched tuft; clypeal hairs *B* and *C* almost side by side; siphon with acus; pecten without detached spines; siphonal tuft subapical.

On account of several peculiarities, chief among which is the unusual length of the hind tarsi—no other *Aëdes* known to me has the first hind tarsal segment as long as the tibia—this species seems to require subgeneric segregation. I therefore propose the name **Rhinoskusea**, subgen. nov.

(7) The Australasian *A. funereus*, Theo., its variety *ornatus*, Theo., and *A. similis*, Theo. These differ from all the other species (except *A. longiforceps*) in having only narrow scales on the scutellum. On this account I have already transferred them to the subgenus *Aëdes*. *A. funereus* also shows some affinity with certain Oriental species of *Aëdes* in the structure of its hypopygium, as well as in having the last few pecten-teeth on the siphon of the larva detached; and a well-developed acus at base of siphon.

## VIII. The Value of the Squamal Fringe as a Generic Character.

In their synopsis of the subfamilies, tribes and genera of American Culicidae (Journ. Wash. Acad. Sci., xiv, 1924, pp. 472–486), Dyar & Shannon introduced several characters which had been overlooked previously, but which appeared to be of value for the diagnosis of genera. Of these characters the one most easily to be seen is the presence or absence of the squamal fringe—that is to say the row of fine hairs which is usually present on the edge of the folded membrane at the extreme base of the wing posteriorly. These hairs (when present) are almost always easy to see under a low power of the microscope, and being in a protected position, are not readily destroyed. Dyar & Shannon noted that the squamal fringe was absent in *Megarhinus* and *Uranotaenia*, absent or incomplete in all the American Sabethine genera, but present in the other genera as represented in America.

I have examined a large number of species in respect of this character, and can fully confirm the opinion of the American writers as to its value for generic definition. Of course it is not to be expected that any one character will provide an absolute criterion in all cases, but here the exceptions appear to be singularly few. So far as I have seen, the squama is quite bare in the following genera: *Megarhinus*, *Uranotaenia*, *Harpagomyia*, *Hodgesia*, *Zeugnomyia*, *Topomyia*, *Wyeomyia*, sens. lat., *Limatus*, *Sabethes*, *Sabethoides*, *Goeldia* (except *longipes* and *trichopus*).

Dyar & Shannon note that the squama bears from one to three hairs in some species of *Wyeomyia* (subgenus *Prosopolepis*), but I have not observed any of these. *Goeldia longipes* and *G. trichopus* are the only species of this genus which have the squama even partially fringed, and it may be pointed out that these two species also differ from the others in having long suberect scales on the second segment of the hind tarsi. These species might well be placed in a separate subgenus on the basis of these two characters.

On the other hand the squama is more or less completely fringed (with 6–10 or more hairs) in the following: *Trichoprosopon*, *Rachionotomyia*, *Haemagogus*, *Heizmannia*, *Eretmopodites*, *Opifex*, *Psorophora*, *Armigeres*, *Aëdes*, *Pardomyia*, *Mucidus*, *Theobaldia*, *Taeniorhynchus*, *Aëdomyia*, *Orthopodomyia*, *Ficalbia*, *Mimomyia*, *Lutzia*, *Culex*, *Deinocerites*.

I have seen no species of any of these genera in which the squama is bare, though the fringe is incomplete or interrupted in *Trichoprosopon* and in a few small species of *Culex*.

# OBSERVATIONS ON THE COCCIDAE OF SOUTHERN RHODESIA.—II.

By W. J. Hall, Ph.D., B.Sc., A.R.C.Sc.,

*Entomologist to the British South Africa Company in Southern Rhodesia.*

The present paper deals with a further 16 species and varieties of Diaspinae of which 9 are believed to be new to science.

In addition to the acknowledgements already made in Part 1* I desire to express my thanks to the Chief Entomologist of the Department of Agriculture, Pretoria, for his kindness in permitting certain authentic material of South African Coccidae from the collections of his Department to be sent to me, and to Mr. H. K. Munro of the same Department for very kindly looking out the material and forwarding it.

**Chionaspis (Phenacaspis) dilatata,** Green.

*Chionaspis dilatata,* Green, Cocc. Ceylon, ii, 1899, p. 148.

*Phenacaspis natalensis,* Cockerell, Ann. Mag. Nat. Hist., (7) ix, 1902, p. 25.

*Phenacaspis natalensis,* Brain, Bull. Ent. Res., x, 1920, p. 100.

*Phenacaspis dilatata,* Hall, Bull. Ent. Res., xix, 1928, p. 287.

A small piece of material was found in the collections of the Department of Agriculture, Salisbury, labelled "*Phen. natalensis,* Ckll., on Mango, Natal Coast, collected by C. Fuller," said to have been determined by and received from Dr. Brain of Pretoria. An examination of this material showed that it was identical with *P. dilatata,* Green, of which I have authentic material. The description and figure of *natalensis* as given by Brain would fit *dilatata* equally well. The name *natalensis,* Ckll., must, therefore, give way to *dilatata,* Green.

Dr. Brain also records *Chionaspis natalensis,* Mask. (Bull. Ent. Res., ix, 1919, p. 232). This was originally described as *C. spartinae* var. *natalensis,* and raised to specific rank by Cockerell in 1902. It may be that this is the same as *Phenacaspis natalensis,* Ckll., in which case the name of *P. natalensis,* Mask., would stand, and *dilatata,* Green, and *natalensis,* Ckll., would have to be sunk. Unfortunately, I have not seen any material of *natalensis,* Mask., nor have I the original description, and consequently no definite conclusions as to this further synonymy can be arrived at. It seems unlikely, however, that Cockerell would have raised Maskell's variety to specific rank and in the same year (1902) have redescribed the same species as *Phenacaspis natalensis.*

**Chionaspis (Dinaspis) distincta,** Leon.

*Dinaspis distincta,* Leonardi, Bol. R. Sc. Agric. Portici, 1914, p. 213.

*Dinaspis distincta,* Brain, Bull. Ent. Res., x, 1920, p. 102.

*Dinaspis proteae,* Hall, Bull. Ent. Res., xix, 1928, p. 289.

A little material, labelled " *Dinaspis distincta,* Leon., on *Protea* sp., Pretoria, coll. C. K. Brain, Oct. 1914," was obtained from the collections of the Department of Agriculture, Salisbury. An examination of this showed that it was identical with my *proteae,* a name that must, therefore, sink.

---

* Bull. Ent. Res., xix, 1928, p. 271.

Note.—Owing to a misunderstanding, the magnifications of the figures as given in Part 1 were incorrect—they should read as follows: Fig. 1, ×240; fig. 2, ×235; fig. 3, ×240; fig. 4A, ×235, 4B, ×140; fig. 5A, ×60, 5B, ×285; fig. 6, ×375; fig. 7, ×330; fig. 8, ×220; fig. 9, ×250; fig. 10, ×260; fig. 11, ×300; fig. 12, ×225; fig. 13, ×280; fig. 14, ×300; fig. 15, ×330.

I was quite misled by Brain's description and figure in this case. He makes no mention of the group of small but conspicuous pores and setae on the prominences that support the median lobes of the pygidium ; also, he places *Chionaspis distorta*, Newst., as a synonym. I have no material of this latter species, but both the description and figure as given by Newstead are totally unlike *proteae*, Hall, or *distincta*, Leon.

**Chionaspis (Dinaspis) reticulata,** Malen.

*Dinaspis reticulata*, Malenotti, Redia, xi, fasc. 2, 1916, p. 343.

*Dinaspis reticulata*, Hall, Bull. Ent. Res., xix, 1928, p. 290.

Mr. Green has recently sent me a little material labelled " *Dinaspis reticulata*, Malen., on *Capparis* sp., Italian Somaliland. Part of type material, coll. F. Malenotti."

I was unaware of the existence of this species which is undoubtedly the same as that which I redescribed under the same name.

**Chionaspis (Dinaspis) dura,** Newst.

*Chionaspis dura*, Newstead, Bull. Ent. Res., x, 1920, p. 205.

*Dinaspis uapacae*, Hall, Bull. Ent. Res., xix, 1928, p. 291.

Mr. Green has very kindly compared preparations of my *uapacae* with the type slide of *dura*, Newstead, and states that he feels practically sure that the two are identical. Newstead described the species from material collected in Uganda on an unknown tree.

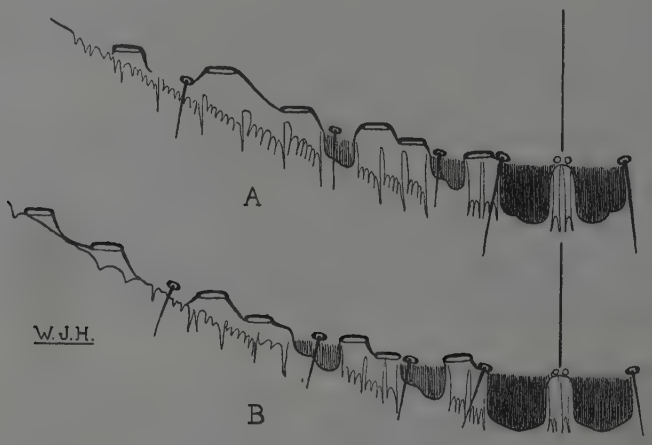



Fig. 1. Part of the pygidium of adult ♀ of : A, *Aspidiotus combreti* var. *zizyphi*, var. n. ; B, *Aspidiotus combreti*, Hall. ×600.

**Aspidiotus combreti** var. **zizyphi,** var. n. (fig. 1).

Differs from typical *combreti*, Hall (Bull. Ent. Res., xix, 1928, p. 273), in the following respects : 1. The puparia of the adult females are not so white ; usually they are dull white or dull brown owing to the incorporation of foreign matter. Specimens on *Zizyphus* frequently lie beneath the surface tissues of the bark, but this covering tissue is so thin that the colour and texture of the underlying puparium can readily be seen, and it could hardly be detected if it were not that the striations of

the bark continue unbroken across the puparia. 2. The circumgenital glands are consistently rather fewer—anterior laterals 1–7, posterior laterals 1–6 ; average of 18 examples 4 : 3. Occasionally one or even two of the glands from the anterior groups are displaced centrally. 3. The much greater development of the seta arising from the base of the outer edge of the median lobe on each side. 4. The tendency for a greater number of squamae to be present beyond the 2nd lateral lobes. Further material of *combreti* collected since the original description was drawn up shows that there is sometimes a greater development of squamae beyond the 2nd lateral lobes than was figured, but it is unusual for as many to be present as in the variety *zizyphi*. 5. The lobes are slightly smaller, and the median pair are of a somewhat different form, exhibiting a notch on the outer edge.

On *Zizyphus jujuba* (Rhamnaceae), Mazoe, 18.i.1928, and *Acacia* sp. (Leguminosae), Umvukwes, 16.vii.1928 ; on the smaller branches.

This variety comes very close to *combreti*, but the differences are sufficiently well marked and consistent to separate it without difficulty.

**Aspidiotus furcillae,** Brain, 1918.

On *Berlinia globiflora* (Leguminosae), Glendale, 17.vi.1928 ; on the branches.

This has been compared with some typical South African material. Rhodesian specimens are relatively smaller, but have rather more circumgenital glands—anterior lateral group 6–13, posterior lateral group 4–8 ; average of 20 examples 8 : 6. In most examples the median group is represented by a single gland, and in a few cases 2 or 3 were present. The spines on the pygidium, also, tend to be longer, and the anal orifice relatively smaller, than in the S. African specimens. In all other respects it resembles *furcillae* so closely that I have no hesitation in assigning the Rhodesian specimens to this species.

**Aspidiotus mashonae,** sp. n. (fig. 2).

Puparium of adult female circular to broadly oval, moderately convex. Exuviae more or less central and brown in colour. Secretionary area a dirty white or dull brown. Ventral scale, extremely thin, remaining attached to the host plant as a thin white film. Diameter 1–1·5 mm.

Male puparium of normal form ; exuviae straw coloured, secretionary area dirty white.

Adult female pyriform to broadly pyriform in outline. Antennae represented by minute tubercles each carrying a single, stout, slightly curved bristle. Parastigmatic glands wanting. The cephalothorax with setae at more or less regular, but wide, intervals all round the margin. Abdominal segmentation distinct with usually two short tubular spinnerets marginally of each segment ; the thoracic segments also carry one or two in a similar position. Pygidium triangular, rounded at the apex. Median lobes set close together, rounded and notched on both inner and outer edges. 1st lateral lobes smaller than the median pair, narrower but of similar form ; other lobes wanting or inconspicuous. There are two incisions in the margin on either side ; that betwen the median and 1st lateral lobes has markedly thickened edges, the inner edge having a very much larger and more conspicuous thickening than the outer ; the 2nd incision—just beyond the 1st lateral lobe—has either edge equally thickened, but it is not nearly so marked as in the case of the 1st incision. Two fringed squamae arise from the vicinity of the 1st incision, and three from that of the 2nd. Beyond the 2nd incision are three spiniform squamae of such a delicate nature that they are frequently broken off or difficult to discern. The chitinisation of the tissues of the pygidium stops short just within the margin in their vicinity. They are situated on broad conical projections of the margin, and at the junction of each squama and its conical base, on the inner edge, is a minute orifice. Circumgenital glands in four

groups—anterior laterals 3–7, posterior laterals 2–5 ; average of 20 examples 4 : 3. Anal aperture small, set near the apex of the pygidium. Dorsal pores not numerous, usually in two series on either side, supplied with long tubular spinnerets. Chitinous markings of the pygidium in well-defined areas exactly as in *Diaspidiotus mazoeensis* (fig. 5).

On *Combretum* sp. (Combretaceae), Mazoe, 26.i.1928, and on an unknown plant, Mazoe, 18.i.1928 ; on the leaves.

This species only differs from *Diaspidiotus mazoeensis* in the following : 1. The presence of a well-developed pair of lateral lobes. 2. The median lobes are relatively smaller. 3. The shape of the thickening on the inner edge of the 1st lateral incision is of slightly different form. 4. There are usually three fringed squamae in the vicinity of the 2nd lateral incision.

*A. mashonae* is also closely allied to *Hemiberlesea zizyphi* and its variety *securidacae*, but the presence of lateral lobes precludes it from being assigned to the subgenus *Diaspidiotus*, and as it possesses circumgenital glands, it cannot be placed as a *Hemiberlesea*. We have, therefore, three closely allied forms which, following the usual classification, have to be assigned to three different subgenera.

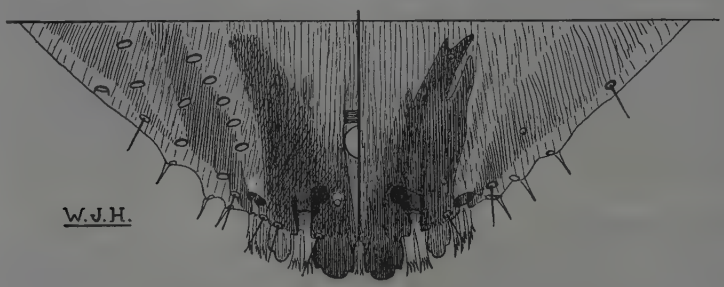



Fig. 2. *Aspidiotus mashonae*, sp. n. : part of the pygidium of adult ♀. ×450.

Both *A. mashonae* and *Diaspidiotus mazoeensis* come close to *Diaspidiotus pectinatus*, Lind., but are quite distinct from some authentic South African material with which they have been compared.

**Aspidiotus msolonus,** sp. n. (fig. 3).

Puparium of adult female pure white, more or less circular and highly convex. Larval exuviae shiny brown green, pale at the margin ; nymphal exuviae brown, also paler at the margin. The exuviae are usually a little to one side. The colour of the exuviae is masked by a semi-opaque thin white secretionary film; that part covering the larval exuviae is occasionally wanting, having presumably been knocked off. The secretionary film is thinner in the vicinity of the margin of the nymphal exuviae, since the pale brown belt round the margin can often be seen through the film as a pale brown ring. Ventral scale extremely thin and delicate, remaining attached to the host plant. Diameter 1·25–1·75 mm.

Male puparium of normal form, white, with brown exuviae.

Adult female approximately circular, with antennae represented by minute tubercles each carrying a curved bristle and a much shorter straight seta ; the bristle is sometimes forked or frayed at the tip. Parastigmatic glands wanting. Margin of the thorax approximately on a line with the anterior spiracles, with a small but

well-developed rounded tubercle. Free abdominal segments with a group of pores at the margin of each segment. Pygidium broadly rounded with three pairs of lobes. Median pair longer than broad with sides subparallel, notched on the outer edge and sometimes with a very faint notch on the inner edge, rounded apically and set apart by a distance rather more than half the width of one. First lateral lobes slightly smaller than the median pair, notched on the outer edge and rounded apically. Second lateral pair broader at the base than either of the other two pairs, but shorter, rounded apically, and with a conspicuous notch on the outer edge. The interval between the 1st and 2nd lateral lobes is rather more than between the median and 1st lateral lobes; in some specimens it is even as much as twice as great. Squamae finely fringed, small and rather inconspicuous, not extending beyond the lobes. Marginal pores occur one between the median lobes, one between the median and 1st lateral lobes, two between the 1st and 2nd lateral lobes, one immediately beyond the 2nd lateral lobe, and three or four at intervals towards the base of the pygidium on

Fig. 3. *Aspidiotus msolonus*, sp. n.: pygidium of adult ♀. ×225.

either side. These pores are supplied with long tubular spinnerets. Dorsal pores, similar to the marginal pores, occur in three short series, from between the 1st and 2nd lateral lobes, from just beyond the 2nd lateral lobes, and from a point wider out. There are usually two or three pores running back from between the median and 1st lateral lobes. Anal orifice rather large, oval, situated towards the apex of the pygidium. Circumgenital glands in either four or six groups. In the four normal groups the anterior laterals vary from 6 to 11, posterior laterals from 1 to 6—average of 20 examples 8 : 4. Not infrequently one gland from an anterior group is displaced centrally, and in one example one from each group was displaced towards the centre. In many examples two extra groups of glands are represented, one on each side wide of the posterior laterals, containing from 1 to 4 glands; in some cases the two extra groups occur on the same side of the pygidium whilst in others only a single extra group is represented. Genital aperture on a line with the posterior lateral groups of circumgenital glands.

On *Pseudolachnostylis maprounaefolia* (Euphorbiaceae), Mazoe, 6.ii.1928, and Lomagundi, Sipolilo, ex. coll. Dept. of Agriculture, Salisbury, No. 1569. Also on *Pseudolachnostylis* sp., Darwendale, 14. xii, 1927. Chiefly on the upper surfaces of the

leaves, on which the dead white puparia of the adult females are very conspicuous. The native name for this tree is ' Msolo.'

This species is remarkable for the presence, in many cases, of six groups of circumgenital glands. In the two first mentioned lots of material, 50 per cent. of the individuals showed six groups, in the last named only one out of 26 specimens showed the presence of the additional groups. The individual selected as the type specimen has six groups of circumgenital glands.

**Aspidiotus vernoniae,** sp. n. (fig. 4).

Puparium of the adult female more or less circular in outline, low convex, and pale brown in colour. Secretionary covering semi-transparent white and rather thick. Exuviae pale brown ; larval exuviae with a median longitudinal carina ; nymphal exuviae not apparent owing to the secretionary covering and the uniform colouration

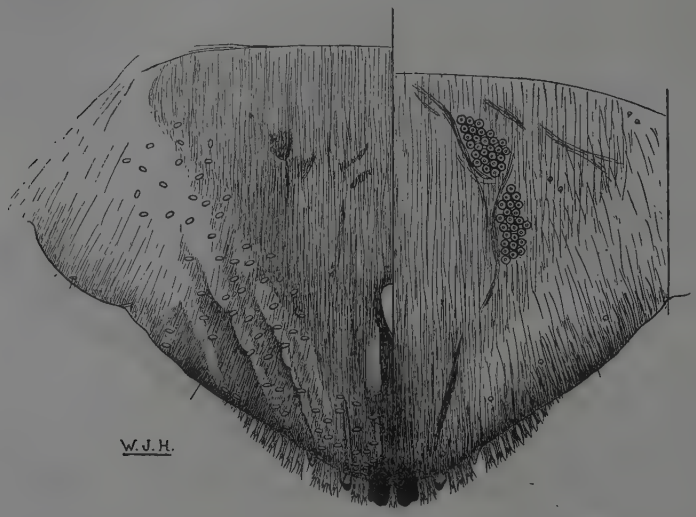



Fig. 4. *Aspidiotus vernoniae*, sp. n.: pygidium of adult ♀. ×225.

of the exuviae and secretionary area. Ventral scale thin and poorly developed, remaining adherent to the host plant. Diameter 2 mm. Puparia usually hidden under the surface tissues of the plant. Where the puparia are completely hidden, the colour is whiter owing to the secretionary covering being of a more opaque white, masking the pale brown colouration of the exuviae and secretionary area.

Male puparia of normal shape, pale brown, covered with a somewhat opaque white secretionary film, which masks the pale brown colour of the exuviae and secretionary area.

Adult female relatively large and more or less circular in outline. Antennae represented by minute tubercles, each carrying a single curved bristle. Parastigmatic glands wanting. Abdominal segmentation not well marked. Lateral margins of free abdominal segments practically devoid of the usual pores, only one or two minute tubular spinnerets to each segment being present. Pygidium triangular, rounded at the apex, with three pairs of lobes ; median pair highly chitinised and conspicuous,

quadrate, rounded at the apex, and with a deep notch on the outer edge; 1st lateral lobes smaller, longer than broad, rounded, and with a notch on the outer edge; 2nd lateral lobes usually triangular but rounded at the tip; in some examples the 2nd lateral lobe on one side or the other apparently wanting. The lateral lobes in contrast to the median lobes are very lightly chitinised. Squamae deeply fringed, two between the median lobes, two between the median and 1st lateral lobes, three between the 1st and 2nd lateral lobes, and ten beyond the 2nd lateral lobe which become successively shorter until they become inconspicuous. Anal aperture elongate pyriform, larger than the median lobes, situated near the centre of the pygidium, but slightly towards the apex. Circumgenital glands in four groups—anterior laterals 22–36, posterior laterals 18–32; average of six examples 27 : 24. In one example, presumably abnormal, there are only 5 in one of the posterior lateral groups. Normally the glands are numerous. Dorsal pores small, scattered, with long tubular spinnerets.

On *Vernonia podocoma* (Compositae), Embeza, 11.iii.1928; on the branches, usually hidden to a greater or lesser degree by the surface tissues of the plant.

Described from 10 examples. It appears to be unlike any other species described from Africa, and possesses well marked characters.

Fig. 5. *Aspidiotus* (*Diaspidiotus*) *mazoeensis*, sp. n.: pygidium of adult ♀. ×337.

**Aspidiotus (Diaspidiotus) mazoeensis,** sp. n. (fig. 5).

Puparium of the adult female circular to broadly oval. Exuviae more or less central and brown in colour. Secretionary area dull brown, the whole covered by a thin secretionary film in which is incorporated particles of the bark of the host plant. The puparia are concolorous with the bark and usually underlying it to a greater

or lesser degree. Ventral scale extremely thin, remaining attached to the host plant as a thin white film. Diameter, 1–1·5 mm. Parasitised females are a reddish brown, darker at the extreme margin.

Male puparia of normal form; exuviae straw coloured, secretionary area dull brown.

Adult female very broadly oval, almost circular. Antennae rudimentary, each consisting of a minute tubercle carrying a stout slightly curved bristle and a minute seta. Parastigmatic glands wanting. The cephalothorax with setae at more or less regular but wide intervals all round the margin. Abdominal segmentation distinct; each segment usually with two short tubular spinnerets marginally; the thoracic segments also carry one or two in a similar position. Pygidium triangular but rounded at the apex. Median lobes set close together, rounded, and notched on both inner and outer edges. Other lobes wanting. There are two marginal incisions on either side of the median lobes, the pair nearest the lobes having conspicuously thickened edges, that on the edge nearest the median line being much larger and more conspicuous than the other. The thickenings on either edge of the lateral incisions are much smaller and less obvious. Two fringed squamae arise from the vicinity of the 1st incision and two from that of the 2nd; the latter may be spiniform, slightly frayed or fringed. Beyond the 2nd incision there are three spiniform squamae of such a delicate nature that they are frequently broken off or difficult to make out; they are situated on broad conical projections of the margin, and at the junction of the squama and its conical base, on the inner edge, is a minute orifice. The chitinisation of the tissues of the pygidium stops short just within the margin in the vicinity of these squamae. Circumgenital glands in four groups, anterior laterals 1–6, posterior laterals 1–6; average of 29 examples 4 : 3. Anal aperture small, set near the apex of the pygidium. Dorsal pores relatively small and few, usually in two series; the pores are supplied with long tubular spinnerets. Chitinous markings of the pygidium conspicuous and in well defined areas.

On an unknown tree, Mazoe, 18.i.1928; on the branches.

This species is very close to *Hemiberlesea zizyphi*, but differs chiefly in the presence of circumgenital glands. It is also near *Diaspidiotus pectinatus*, Lind., from which it differs in the nature of the lateral squamae and in the conspicuously different sizes of the thickenings on either edge of the 1st lateral incision.

In the specimen selected for the type, the circumgenital glands are rather less than the average with one gland from each anterior lateral group displaced a little towards the median line.

**Aspidiotus (Hemiberlesea) camelliae,** Sign. 1869.

On *Acacia mollissima* (Black Wattle), Inyanga, 30.vii.1910, *Smilax* (Liliaceae), Salisbury, 31.v.1911, on a "creeper," Salisbury, 9.vii.1909—all from the collections of the Department of Agriculture, Salisbury.

**Aspidiotus (Hemiberlesea) rhodesiensis** var. **umtalii,** var. n. (fig. 6).

This variety differs from typical *rhodesiensis*, Hall (Bull. Ent. Res., xix, 1928, p. 274), in: 1. The absence of the 2nd lateral lobes to the pygidium (or, if they are represented, they are extremely small and inconspicuous). 2. The median lobes, which are distinctly notched on their outer edges (in some material of *rhodesiensis*, recently collected, the median lobes were similarly notched, but it is unusual). 3. The 1st lateral lobes, which are relatively closer to the median pair. 4. The anal orifice, which is consistently nearer the margin. It seems to be very variable in size, in some cases being smaller, in others larger, than in *rhodesiensis*, but irrespective of size, it is always nearer the margin.

On *Brachystegia* sp. (Leguminosae), Umtali, 1.xii.1927; on the branches.

A long series of examples shows that, whilst this species is near to *rhodesiensis*, it possesses constant small but marked differences.

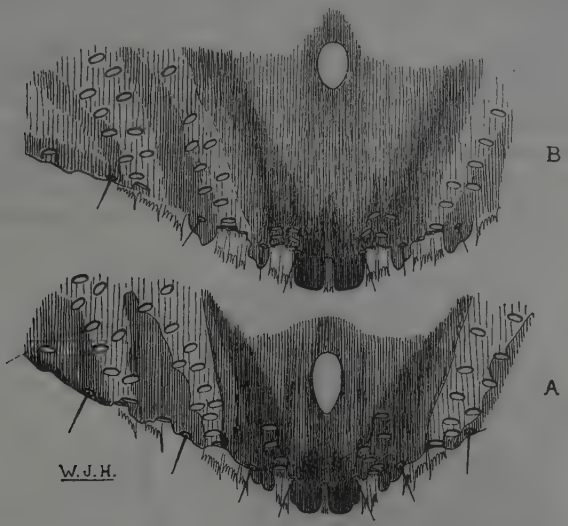



Fig. 6. Part of the pygidium of adult ♀ of: A, *Aspidiotus* (*Hemiberlesea*) *rhodesiensis* var. *umtalii*, var. n.; B, *Hemiberlesea rhodesiensis*, Hall. ×337.

**Aspidiotus (Hemiberlesea) zizyphi,** sp. n. (figs. 7, 8A).

Puparium of the adult female of irregular shape, usually more or less circular in outline. Exuviae generally a little to one side; larval exuviae very pale, but golden brown round the margin; nymphal exuviae a dark purplish brown; the whole covered by a thin dirty white secretionary film, which in some specimens masks the colour of the larval exuviae but not of the nymphal exuviae so that it appears as though there is a whitish boss surrounded by the dark colouration of the underlying nymphal exuviae. Secretionary area very pale brown or dirty white, often with—in the case of examples from *Zizyphus*—minute hairs from the bark of the host plant incorporated. Ventral scale very thin, remaining attached to the host plant. Diameter, 1–1·25 mm.

Male puparium oval to elongate oval in outline. Exuviae very pale, reddish brown at the margin. Owing to the white secretionary covering, they appear to be surmounted by a white boss. Secretionary area dirty white.

Examples on *Flacourtia* were found under the surface tissues of the bark. The exuviae were a very pale yellow with a thin white secretionary film; the secretionary area was white.

Adult female broadly oval to subcircular in outline. Antennae represented by minute tubercles, each carrying a single slightly curved bristle. Parastigmatic glands wanting. The cephalothorax with setae at more or less regular but wide intervals all round the margin. A small rounded thoracic tubercle occurs marginally on each side Abdominal segmentation usually distinct, each segment with 1–3 short tubular spinnerets in the marginal region, the orifices of these being smaller than the dorsal pores on the pygidium. Pygidium triangular but rounded at the

apex. Median lobes set close together, as broad as long, deeply notched on the outer edge, faintly notched on the inner edge, apex rounded. Other lobes wanting. Two incisions on each side of the median lobes, each with a gland orifice at the base. The incisions nearest the median lobes have conspicuous thickenings on each edge, those nearest the median line being more or less semicircular in shape and much the larger and more conspicuous. The lateral incisions have faint thickenings on each edge. Squamae few, two arising from the vicinity of the 1st lateral incision, the outer one being bifid or trifid and usually readily seen, the inner being very difficult to detect but appearing to be either spiniform or frayed at the apex. Two other squamae arise from the region of the 2nd lateral incision; these are generally spiniform, but the outer one is sometimes frayed, and in one example was plate-like and deeply fringed. Anal orifice relatively small, very little larger than one of the median lobes, situated near the apex of the pygidium. Dorsal pores few, but large and conspicuous, in two more or less well defined series running from the margin towards the base of

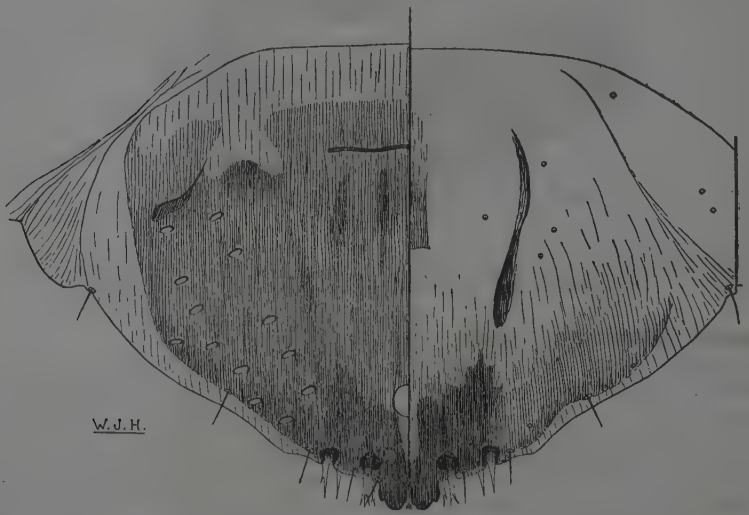



Fig. 7. *Aspidiotus* (*Hemiberlesea*) *zizyphi*, sp. n.: pygidium of adult ♀, ×337.

the pygidium. These pores are supplied with tubular spinnerets of medium length. The pygidium with well defined chitinised areas; the general chitinisation of the pygidium appears to stop short just within the margin. Behind the median lobes, at a distance from the margin about equal to their length, are two broadly oval unchitinised—or not so heavily chitinised as the surrounding tissues—areas at the posterior extremity of which is a minute pore or spine.

On *Zizyphus jujuba* (Rhamnaceae), Mazoe, 30.viii.1927 and 18.i.1928, *Flacourtia hirtiuscula* (Flacourtiaceae), Sinoia, 16.xii.1927; on the small branches, with a few, chiefly male, puparia on the leaves.

This species is near to *camelliae*, but differs from it in several points—the smaller anal orifice, the nature of the squamae and the arrangement of the dorsal pores amongst others. It is also not unlike *Aspidiotus tectonae*, Lind., from which it differs

in the shallower nature of the median notch, the nature of the thickenings to the edges of the 1st lateral incision and the absence of squamae beyond the 2nd lateral incisions.

It is interesting to note that male puparia were present in numbers on all the material.

**Aspidiotus (Hemiberlesea) zizyphi** var. **securidacae,** var. n. (fig. 8B).

Varies from typical *zizyphi* in: 1. The nature of the thickenings to the edges of the lateral incisions, these being more or less of equal size on either side of the incision. 2. The presence of a highly chitinised pore between the 1st and 2nd lateral incisions. 3. The slightly greater number and, with the exception of the two just

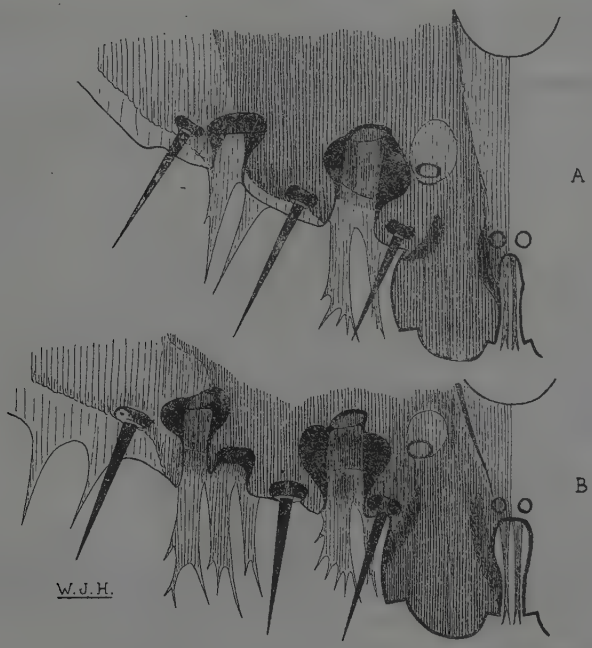



Fig. 8. Portion of the pygidium of adult ♀, ×1125, of: A, *Aspidiotus* (*Hemiberlesea*) *zizyphi*, sp. n.; B, *A.* (*H.*) *zizyphi* var. *securidacae*, var. n.

beyond the 2nd lateral incision, the more conspicuous fraying of the apices of the squamae. 4. The anal orifice, which is slightly nearer the apex of the pygidium. 5. The larger size of the pores on the margins of the free abdominal segments—these being the same size as the dorsal pores on the pygidium and not smaller as in *zizyphi* —and the fact that similar pores occur marginally of the thoracic segments.

The puparia most nearly resemble those of *zizyphi* from *Flacourtia hirtiuscula*, being usually partly hidden by the surface tissues of the host plant.

On *Securidaca longepedunculata* (Polygalaceae), Sinoia, 15.xii.1927, *Cassia tettensis* (Leguminosae), Mazoe, 29.iv.1928, and *Canthium lanciflorum* (Rubiaceae), The Kopje, Salisbury, 1.i.1928; on the small branches, with a few, chiefly male, puparia on the leaves.

This variety is close to *Aspidiotus tectonae*, Lind., but differs in the shallower nature of the median notch, the better development of squamae in the vicinity of the 2nd incision, and in the presence of a highly chitinised marginal pore just median of the 2nd incision.

**Aspidiotus (Selenaspidus) articulatus,** Morgan.

*Aspidiotus articulatus*, Morgan, Ent. Mon. Mag., xxv, 1889, p. 352.

*Selenaspidus articulatus*, Brain, Bull. Ent. Res., ix, 1918, p. 135.

On wild lemon, Garamapudzi River, coll. R. Lane (slide lent for identification by the Department of Agriculture, Salisbury), 13.xi.1928. A single specimen was also taken on a *Ficus* tree in my garden at Mazoe, 3.xi.1928.

These have been compared with authentic specimens of *articulatus* in my collection and found to be identical.

**Aspidiotus (Morganella) conspicua,** Brain.

*Diaspis* (*Epidiaspis*) *conspicua*, Brain, Bull. Ent. Res., ix, 1919, p. 228.

On *Bauhinia macrantha* and *Bauhinia* spp. (Leguminosae), Sinoia, 15.xii.1927, *Canthium lanciflorum* (Rubiaceae), The Kopje, Salisbury, 1.i.1928, *Acacia* sp. (Leguminosae), Umtali, 13.iii.1928, and an unknown plant, El Dorado, 1.xii.1928.

This has been compared with authentic South African material and found to agree perfectly. Mr. Green points out that it should be referred to *Morganella* and not to the subgenus *Epidiaspis* to which Brain assigned it; he states that "all the characters both of the puparium and adult female show the species to be closely allied to *Morganella longispina*, Morgan." Prof. Cockerell (Tech. Bull. No. 6, U.S. Dept. of Agriculture, 1897, p. 22), referring to the subgenus *Morganella*, states that "it will be known by the closely adjacent or contiguous median lobes, which are long and slender, the absence of other lobes, the anal orifice at base of lobes and especially the very long spines." An examination of *conspicua* shows that it agrees in every respect with the above designation.

**Aspidiotus (Chrysomphalus) dictyospermi,** Morgan 1889.

On *Citrus aurantium* (Rutaceae), Mazoe, 27.i.1928.

A moderately heavy infestation of typical *dictyospermi* was found on some orange trees in the homestead garden. The danger of this species spreading from thence to the citrus groves in the immediate vicinity was at once realised, and the trees were fumigated with an overdose of hydrocyanic acid gas.

**Aspidiotus (Chrysomphalus) rossi,** Mask. 1890.

On a palm and on *Pinus* sp., Bulawayo Park, 4.x.1928, and *Grevillea robusta*, Bulawayo, 20.x.1928.

**Aspidiotus (Aonidiella) gowdeyi,** Newst.

*Aspidiotus gowdeyi*, Newstead, Bull. Ent. Res., iv, 1913, p. 77.

*Hemiberlesea fissidens* var. *constricta*, Malenotti, Redia, xi, fasc. 2, 1916, p. 340.

*Aspidiotus gowdeyi*, Brain, Bull. Ent. Res., ix, 1918, p. 123.

On *Chrysophyllum argyrophyllum* (Sapotaceae), Mtoroshanga Pass, Umvukwes, 5.viii.1928; in very large numbers on the upper surface of the leaves.

Rhodesian examples have been compared with South African and Uganda material. All differ from the original description in the nature of the three squamae immediately beyond the 2nd lateral lobe; these instead of being of the broad and very finely

fringed type as figured by Newstead (*l.c.* fig. 9, c) are like the two proximal ones that he figures as 9, b. Brain, in recording this species from South Africa, quotes Newstead's original description, but figures it, so far as the lateral squamae are concerned, differently, namely, as I have found them in all the material I have examined.

Newstead makes no mention of the fact that there is a sharply defined chitinous margin to the cephalothorax. This is exhibited in all the specimens I have studied.

Mr. Green has recently sent me a little material of *Hemiberlesea fissidens*, Lind. var. *constricta*, Malen., from Italian Somaliland. This appears to me to be identical with *gowdeyi*. The differences between material from Uganda, Somaliland, South Africa, and Rhodesia are negligible. Rhodesian specimens are most like those from Somaliland.

The presence of well-developed paraphyses and the absence of circumgenital glands suggests that this species belongs to Leonardi's subgenus *Aonidiella*, to which I have assigned it.

It would appear from Lindinger's description of *fissidens* that this is a different species, being larger and with the squamae of the pygidial fringe of a different nature.

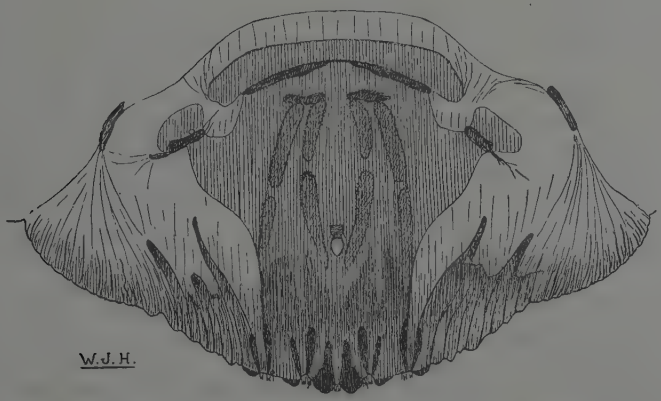



Fig. 9. *Aspidiotus* (*Aonidiella*) *monotes*, sp. n.: pygidium of adult ♀, ×225.

**Aspidiotus (Aonidiella) monotes,** sp. n. (fig. 9).

Puparium of the adult female circular in outline and very highly convex, being almost as high as broad. Larval exuviae dark purplish brown with a thin covering film of a white or greyish colour—this is frequently knocked off and sometimes the larval exuviae themselves are missing; nymphal exuviae and secretionary area jet black; beyond the exuviae the surface is beset by minute concentric striations or growth lines. The exuviae can be removed and come away as a rounded cone, uncovering a smooth shiny black surface. Layers can be flaked off the puparium, leaving invariably the shiny black surface beneath. The ventral scale is very well developed. If the puparium is raised the ventral scale splits micawise, half remaining attached to the host plant and the other half to the dorsal scale: consequently, when the puparium is removed, the adult female is enclosed in a hard capsule composed of the dorsal and part of the ventral scales. That part of the ventral scale which remains attached to the host plant is thick, flat in the centre with a much thickened and upturned margin; generally white or greyish in all but the marginal region.

If it is raised from the host plant, it is found to be jet black beneath. The dorsal scale is turned under marginally and forms a distinct angle at the junction with the upturned ventral scale.

The adult female, being very soft bodied, is extremely difficult to extract from its hard capsular home without damage. The most satisfactory method was found to be to break down the puparium *in situ* on the host plant, working a hole in the apex with a razor blade and needles and finally lifting the soft-bodied female out. The adult female occupies very nearly the entire cavity, even when dead, and, apart from the pygidium, the tissues are extremely thin and delicate. Diameter 0·6–0·9 mm., height 0·6–0·9 mm.

Adult female apparently more or less circular in outline. Antennal tubercles with a small, much curved bristle. Parastigmatic glands absent. Abdominal segmentation distinct, with the margins of the free abdominal segments produced laterally; the pores on the lateral extensions extremely few and minute. Pygidium broadly rounded but flattened, being much broader than long. There are three pairs of lobes, which are all broader than long, flattened and comparatively inconspicuous. The 1st lateral lobes are smaller than the median pair and much the same size as the 2nd lateral pair. The lateral lobes are notched on their outer edges, and the median pair sometimes have a minute notch on the inner edge in addition. There are two minute fringed squamae between the median lobes, median and 1st lateral lobes, and 1st and 2nd lateral lobes. Five pairs of paraphyses are present, a pair between the median lobes in which the paraphyses are of equal length, a pair between the median lobes and 1st lateral lobes of which the inner is usually slightly longer and stouter than the outer, and a pair between the 1st and 2nd lateral lobes in which the inner is slightly longer but usually no stouter than the outer. Anal orifice small, situated near the centre of the pygidium. Pygidium entirely lacking dorsal pores. A few minute tubular spinnerets occur ventrally, more particularly towards the base of the pygidium. Pygidium heavily chitinised, the chitinisation following a more or less constant pattern as indicated in the figure. Circumgenital glands wanting.

On *Monotes glaber* (Dipterocarpaceae), Trelawney, 29.iii.1928; more especially in the crevices on the smaller branches.

The whitish centres of the ventral scales where the puparia had been knocked off led to the discovery of this species. The puparia themselves in the crevices are most inconspicuous. The position of some of the ventral scales on the smooth surface of the branches indicates that they do not always occupy crevices. Presumably they would be easy to see when in such a position, but on the shrub attacked every one of the scales thus exposed had been knocked off.

The characters of this species are very distinctive and should serve to distinguish it readily from allied species.

# OBSERVATIONS ON THE COCCIDAE OF SOUTHERN RHODESIA.—III.

By W. J. Hall, Ph.D., B.Sc., A.R.C.Sc.,

*Entomologist to the British South Africa Company in Southern Rhodesia.*

**Pseudaonidia tesserata,** de Charm.

*Aspidiotus* (*Diaspidiotus*) *tesseratus,* de Charm., Pr. Soc. Amic. Scien., 1899, p. 23.

*Pseudaonidia tesserata,* Brain, Bull. Ent. Res., ix, 1919, p. 206.

On *Monotes glaber* (Dipterocarpaceae), Trelawney, 29.iii.1928. The specimens were found on the larger branches (1½ inches in diameter) underneath the superficial tissues of the bark.

Rhodesian examples agree with a little South African material that I have and also with the description and figure of the species as given by Brain. Mr. Green informs me that "it is not quite typical of de Charmoy's *tesserata.* A noticeable difference from the type is in the more numerous and stronger marginal setae, which extend on to the thorax and frons. In typical *tesserata* they are sparse, relatively short and confined to the abdomen." This being the case it would seem that South African (Brain describes a marginal series of long—57 $\mu$—hairs at wide intervals) and Rhodesian material should be considered as a variety of *tesserata,* but I do not feel justified in making a new variety without first examining specimens of true *tesserata* or at least studying the original description.

**Parlatoria fluggeae,** sp. n. (fig. 1).

Puparium of the adult female broadly oval. Larval exuviae brown, brown-green or sea-green; nymphal exuviae brown or brownish green. The margin in both larval and nymphal exuviae is brown. The exuviae are situated just within the margin. Nymphal exuviae $\frac{1}{3}$ $\frac{5}{12}$ the length of the puparium. Secretionary area dirty white, often with minute portions of the bark incorporated. The specimens are so mixed up with the surface tissues of the bark that it is difficult to make out the true characters of the puparia. Ventral scale very thin and delicate, remaining adherent to the host plant. Length, 1–1·25 mm.; breadth, 0·75–1 mm.

Adult female more or less circular in outline. Antennal tubercles with the usual small slightly curved bristle. Anterior spiracles with a group of 6–13 parastigmatic glands; this group is not compact, and as a rule no two glands are touching. Abdominal segmentation distinct. Lateral margins of the two posterior segments with 5 or 6 gland spines; these are swollen at the base, and sometimes two spines arise from one base. There is a single gland spine in the posterior lateral angle of the margin of the anterior abdominal segment. Margin of all free abdominal segments with a group of short tubular spinnerets, the posterior thoracic segment also carrying a smaller group of similar glands in a like position. The thorax and cephalothorax, marginally, with a few minute tubular spinnerets set in small tubercles. Pygidium broadly rounded with four pairs of lobes. The median lobes are separated by a distance rather less than half the width of one, and they are notched on the inner edge, rounded at the tip, with a sloping double-notched outer edge. First and 2nd lateral lobes of similar shape to the median pair but smaller, with the notch on the inner edge absent or very faintly developed. The 3rd lateral lobe is separated from the 2nd by a distance greater than that separating the 1st and 2nd lobes. It is of similar form and just as broad but much shorter and very conspicuously notched; the majority of examples show it to be twice-notched but some have as many as four notches. The 2nd lateral lobe in some cases has three notches. There is an indication of a 4th pair of lateral lobes represented by a serrated tubercle set far out

(7130) Wt P5/3 521 1,100 12/29 H & Sp Gp 52

near the base of the pygidium. A pair of narrow squamae occur between the median lobes, between the median and 1st laterals, and the 1st and 2nd laterals on each side. These squamae are not conspicuous; they are of a slender nature frayed somewhat towards the apex. A heavily chitinised marginal pore is found between the median lobes, and three others occur on each side, these being slightly larger than the dorsal pores. Between the 2nd and 3rd lateral lobes and between the 3rd lateral lobes and the base of the pygidium are a series of spiniform squamae of somewhat irregular form; they consist normally of a stout spiniform process arising from a much swollen base or tubercle, which is often of irregular form and may even carry a few serrations. Anal orifice small, set near the centre of the pygidium. Circumgenital glands in four groups—anterior laterals 10–19, posterior laterals 11–19; average of 13 examples 14 : 15. In six examples from 1 to 4 glands were found in

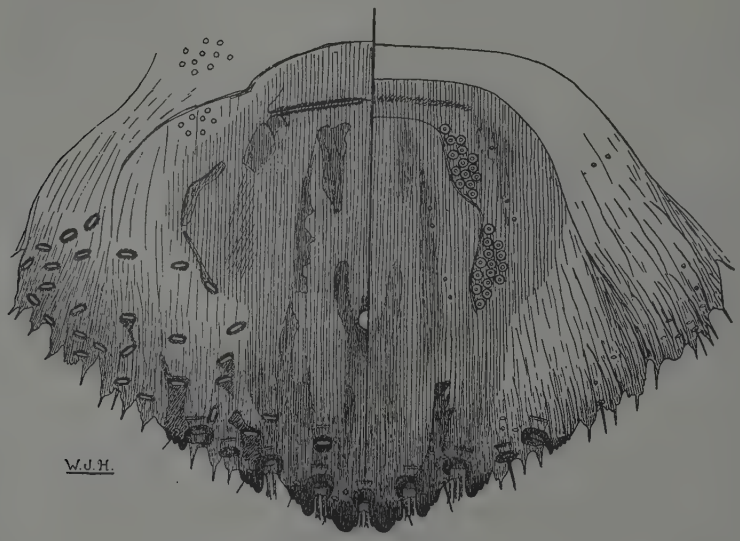



Fig. 1. *Parlatoria fluggeae*, sp. n.: pygidium of adult ♀, ×337.

a median position; the indications are that these represent a median group and are not glands belonging to the anterior lateral groups displaced centrally. In one example two glands were found between the anterior lateral group and the base of the pygidium. Dorsal pores scattered and rendered conspicuous by the chitinisation of the ring of tissue immediately surrounding them. At the base of the pygidium, midway between the margin and the median line, is a small group of much smaller tubular spinnerets.

On *Fluggea microcarpa* (Euphorbiaceae), Umtali, 2.xii.1927; on the branches.

This species comes near to *P. oleae*, Colvée, from which it differs in having only four well-defined groups of circumgenital glands, in the form of the lateral lobes, and in the strong development of the 3rd pair of lateral lobes.

**Howardia dombeyae,** sp. n. (fig. 2).

Puparium of the adult female more or less circular in outline and convex. Larval exuviae shiny brown with a median longitudinal carina. Nymphal exuviae usually

a paler brown and rather large, occupying about $\frac{2}{3}$ of the puparium. Exuviae with a very thin white secretionary covering film, which is often missing over the larval exuviae. Secretionary area white, but appearing dirty white or brown owing to particles of incorporated matter. Ventral scale extremely thin and delicate, remaining adherent to the host plant. Diameter, 1·0–1·5 mm.

Adult female circular in outline with antennae represented by minute tubercles each carrying one or two stout curved bristles and two minute setae. Anterior spiracles with a compact rounded group of parastigmatic glands; it is not easy to make out the number of these, but they appear to vary from 10 to 15. Abdominal segmentation marked. The last two free segments with a transverse row of short tubular spinnerets midway between the margin and the median line lying along the junction of the segment with that next posterior; a group of similar glands also occurs marginally. These glands are similar to those found midway between the margin and the base of the pygidium. Margin of anterior abdominal segment and

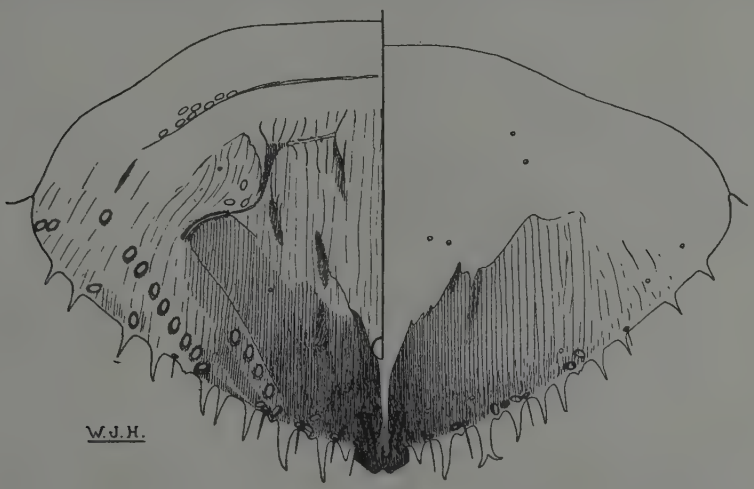



Fig. 2. *Howardia dombeyae*, sp. n.: pygidium of adult ♀, ×225.

thoracic segments with a few minute tubular spinnerets. Abdominal segments with a small group of aciculate gland spines marginally. Pygidium triangular, rounded at the apex. Median lobes in close apposition, rounded, with apex near the median line, thence falling away obliquely with four or five small but marked serrations on the outer edge; highly chitinised. A pair of conspicuous, slightly divergent, stout, truncheon-shaped paraphyses project inwards from the median lobes. Other lobes wanting. A minute jagged projection occurs midway between the median line and the base of the pygidium. Squamae large and spiniform, usually ten on either side; that nearest the median lobes is smaller than the others and the form is not easily discernible. The third squama from the median line is the largest; in some examples it is truncate at the apex, in others it is deeply bifid, whilst in others it is spiniform. The squamae towards the base of the pygidium tend to be smaller. Dorsal pores large and conspicuous, with short tubular spinnerets, in two marked interrupted series one running back from the 3rd lateral squama and the other from about the 6th. Each series consists of a marginal group and a further group of somewhat smaller pores midway between the median line and the margin. Anal orifice small,

situated towards the apex of the pygidium. Circumgenital glands wanting. The chitinisation of the tissues of the pygidium follows well-defined lines leaving a median V-shaped area, running down to the median lobes, unchitinised.

On *Dombeya rotundifolia* (Sterculiaceae), Rusape, 16.iii.1928, Macheke, 11.vi.1928, and Salisbury, 30.v.1917, ex coll. Dept. of Agric., Salisbury, no. 874 ; on the smaller branches.

A species with well-marked characters. The margin of the pygidium is not unlike *Lepidosaphes moorsi*, Doane & Ferris, which Mr. Green has recently shown to be synonymous with *L. hawaiiensis*, Mask. (Ann. Mag. Nat. Hist. (10), i, 1928, p. 152).

**Diaspis subregularis,** sp. n. (fig. 3).

Puparium of the adult female more or less circular, convex but flattened at the margin. Exuviae tilted forward ; within the margin, but to one side. Larval exuviae pale brown ; nymphal exuviae pale brown, but darker at the margin. Secretionary area semitranslucent white with a frosted appearance, translucent at

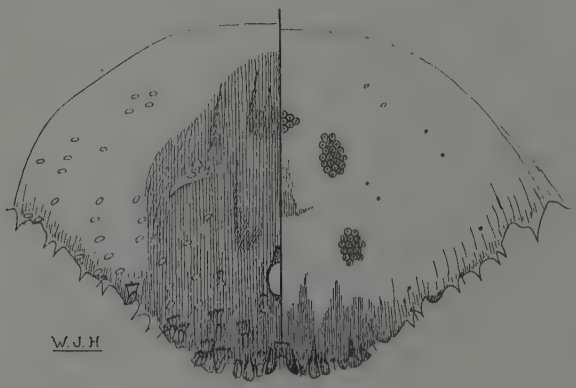



Fig. 3. *Diaspis subregularis*, sp. n. : pygidium of adult ♀, ×225.

the margin with sometimes a faint tinge of brown. The brown coloration of the pygidium of the adult female can be seen through the puparium. Ventral scale wanting. Diameter, 1–1·2 mm.

Male puparium white and very strongly tricarinate ; exuviae pale brown.

Adult female broadly pyriform ; abdominal segmentation distinct, the margins of the segments being produced laterally. Rudimentary antennae with a single stout curved bristle. Anterior spiracles with 1–4 parastigmatic glands. Marginal region of the free abdominal segments with a large number of short tubular spinnerets, a few also occurring laterally of the last thoracic segment. The last two free abdominal segments with usually four aciculate gland spines and a more conspicuous spine at the posterior lateral angle. Pygidium broadly rounded with three pairs of lobes. The median pair are recessed, slightly divergent, very faintly serrated on their inner edges, and separated by a distance that is about the width of one. First and 2nd lateral lobes duplex, the 1st lateral pair with the inner lobule rather longer but no broader than the outer, which is very slightly dilated at the apex, and the 2nd lateral lobes with the lobules broader than in the 1st pair, but shorter and more markedly dilated. Between the 1st lateral lobes and the median pair, and between the 1st

and 2nd lateral lobes there is a lobe-like pore-carrying projection. Just beyond the 2nd lateral lobes are two projecting pores set close together, and wider out a conspicuous projection of a similar nature which is rounded and obscurely spinose. Squamae simple and small, two between the last two marginal pores, and four between the last and the base of the pygidium. Marginal pores larger than the dorsal pores. In addition to the series of marginal pores, two pores of a similar nature, longitudinally orientated, occur within the margin, one behind the inner lobule of the 1st lateral lobes and one just median of the inner lobule of the 2nd lateral lobes. Dorsal pores with short tubular spinnerets and without any apparent arrangement. Circumgenital glands in five groups—median group 8–20, anterior laterals 10–25, posterior laterals 13–24; average of 18 examples 14 : 20 : 16. In five examples the median group was divided into two transverse groups one behind the other, the outer group represented by 1–9 glands which are always in a transverse single line and not bunched as in the case of the main group. In a single example one anterior lateral group had three glands detached, forming a secondary group outside in the same way. Anal orifice relatively large, set towards the apex of the pygidium.

On *Loranthus* sp. (Loranthaceae), Rusape, 16.iii.1928, Macheke, 11.vi.1928, *Carissa arduina* (Apocynaceae), Mtoroshanga Pass, Umvukwes, 5.viii.1928, and an unknown host plant, ex coll. Dept. of Agric., Salisbury; on the leaves.

This species comes close to *regularis*. Mr. Green has very kindly compared it with typical examples of *regularis* in his collection and states that "the trullae and marginal fringe are exactly as in *regularis* but the dorsal pores are larger and longitudinally elongate, whereas in *regularis* they are smaller and oblate. There is also the marked difference in the dentiform process, though, if other characters were in complete agreement, I should not regard this as of more than varietal importance. The puparia are more like those of *regularis* than are those of your No. 265 (*subregularis* var. *spatulata*) which is otherwise very near No. 272 (*subregularis*)."

**Diaspis subregularis** var. **spatulata,** var. n. (fig. 4).

Puparium of the adult female more or less circular and low convex. Larval exuviae pale brown, marginal; nymphal exuviae of a similar colour, but usually darker round the margin. Secretionary area semitranslucent fulvous. Ventral scale wanting. Diameter, 1·5–2 mm.

Male puparium white and very strongly tricarinate; exuviae pale brown.

The adult female differs from typical *subregularis* in the following points: (1) It possesses a distinct thoracic tubercle. (2) Free abdominal segmentation not so clearly defined. (3) Free abdominal segments with much fewer, but slightly larger, pores; the anterior free segment is devoid of these pores. (4) The aciculate gland spines on the last two free abdominal segments are longer and more conspicuous, but the projection at the lateral angle of the segment is relatively not so conspicuous. (5) The median lobes are slightly closer together and narrower. (6) The lateral duplex lobes are a little larger, and in the case of the 2nd pair the lobules are very conspicuously dilated. (7) The last marginal pore is set in a conspicuous spine such as in *regularis*, Newst. (8) The spiniform squamae are much larger. (9) The tubular spinnerets to the dorsal pores are slightly longer. (10) Circumgenital glands fewer—median group 7–9, anterior laterals 12–16, posterior laterals 8–10; average of 13 examples 8 : 13 : 8. (11) There is a longitudinally orientated pore within the margin between the median lobes—in *subregularis* this is marginal and transversely placed.

On *Sapium mannianum* (Euphorbiaceae), Embeza, 11.iii.1928; on the leaves.

Both *subregularis* and the variety *spatulata* come close to *regularis*, Newst., and *africana*, Lind. There are obvious differences from both of these; in some respects they resemble the former and in others the latter, but without an examination of authentic material it is not possible to say whether they might be placed as varietal

forms of one or the other. Mr. Green has very kindly compared my var. *spatulata* with typical specimens of *regularis* and states " it is near *regularis* but differs in the flattish, translucent, fulvous puparia (as opposed to the strongly convex opaque white puparia of *regularis*), in the smaller number of perivulvar pores and in the more prominent and markedly dilated lateral trullae. Nor are the puparia orientated in the manner peculiar to *regularis*."

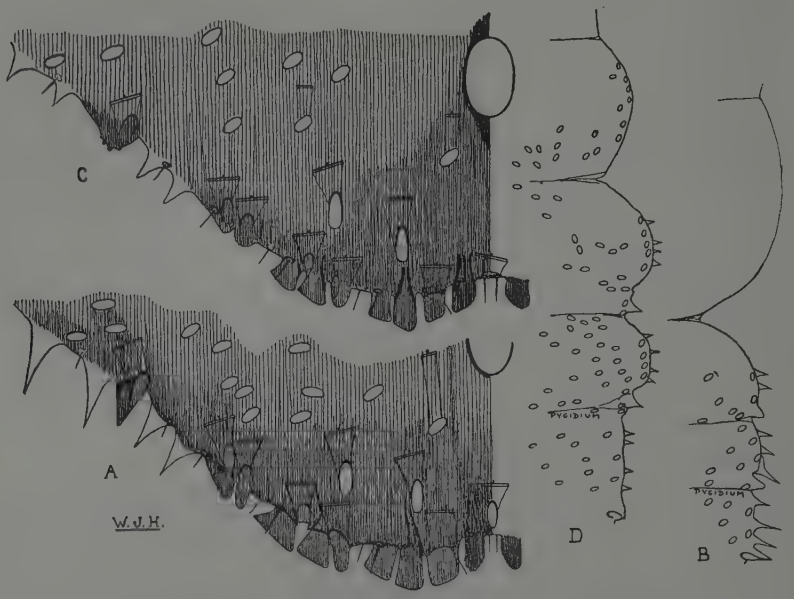



Fig. 4. Part of the pygidium of adult ♀, ×570, of: A, *Diaspis subregularis* var. *spatulata*, var. n.; C, *Diaspis subregularis*, sp. n.

Margin of free abdominal and basal pygidial segments, ×170, of: B, *D. subregularis spatulata*; D, *D. subregularis*.

**Chionaspis chaetachmae,** Brain.

*Chionaspis chaetachmae*, Brain, Bull. Ent. Res., ix,1919, p. 235.

On *Phoenix dactylifera* (Palmae), Mtoroshanga Pass, Umvukwes, 16.vii.1928; on the leaves.

This has been compared with four authentic South African specimens and found to agree in all essential details.

**Chionaspis chaetachmae** var. **imbricata,** var. n.

This differs from typical *chaetachmae* in the following respects: (1) Both the adult female and its puparium are broader, but no longer. (2) The median lobes of the pygidium are set more widely apart and instead of being uniformly rounded at the apex are unevenly rounded, the apex being nearer the outer edge. (3) The squamae on the pygidium are relatively longer. (4) There are usually fewer pores in the last row of dorsal pores, and rarely as many as 7–9 as quoted for *chaetachmae*. (5) The

chitinisation in old individuals of all but the pygidium and posterior free abdominal segment. (6) The ventral dermis, bounded by the anterior spiracles and a line joining the anterior and posterior spiracles on either side, with scattered minute pyramidical spines. These can readily be seen under the low power of the microscope as a number of minute black spots. They are continued behind the posterior spiracles on to the first two free abdominal segments, but get smaller and tend to be grouped in transverse rows, each group containing 6 or 7 minute spines recalling the imbrications found in certain species of Aphids. The spines can readily be seen in young and unchitinised specimens, but they are not quite so conspicuous in the older highly chitinised individuals.

On an unknown tree, Mtoroshanga Pass, Umvukwes, 19.vii.1928 ; on the leaves and branches.

This species can easily be distinguished from both Rhodesian and South African material of *chaetachmae* by the greater space between the median lobes, the greater width of the female and its puparium, the chitinisation of the tissues, and the presence of scattered minute spines on the ventral thoracic dermis.

The specimen selected as the type is an early adult female before the chitinisation has set in. The number of circumgenital glands in the median group in this specimen is abnormal ; usually 4–9 are present as in typical *chaetachmae*.

**Chionaspis exalbida,** Ckll.

*Chionaspis exalbida*, Cockerell, The Entom., xxxv, 1902, p. 112.

*Chionaspis exalbida*, Brain, Bull. Ent. Res., ix, 1919, p. 230.

On *Aloe* sp. (Liliaceae), Greenwood Park, Salisbury, 12.xii.1927 and 2.iii.1928 ; on the leaves.

A number of *Aloe* plants were found very heavily infested with this species. The specimens agree with Brain's description and figure.

**Chionaspis fici,** Newst.

*Chionaspis fici*, Newstead, Bull. Ent. Res., vii, 1917, p. 379.

On *Terminalia sericea* (Combretaceae), El Dorado, 14.xii.1927 and 1.xii.1928, *T. torulosa*, Sinoia, 16.xii.1927, and *T. sericea*, Mazoe, 25.i.1928.

Mr. Green has very kindly compared some of this material with a little of Newstead's type material. Rhodesian examples appear to have narrower puparia than Newstead describes, but as it is a variable species, too much stress cannot be laid on this.

**Chionaspis stanotophri,** Cooley.

*Chionaspis stanotophri*, Cooley, Special Bull. Mass. Expt. Sta., 1899, p. 35.

*Chionaspis stanotophri*, Brain, Bull. Ent. Res., ix, 1919, p. 233.

On *Cymbopogon giganteus* (Gramineae), Embeza, 11.iii.1928.

**Chionaspis (Pinnaspis) communis** var. **diospyros**, var. n. (fig. 5).

This variety differs from typical *communis*, Hall (Bull. Ent. Res., xix, 1928, p. 284), in the following characters : (1) The squamae on the pygidium are much larger and more conspicuous. (2) The posterior two free abdominal segments with squamae similar to those found on the pygidium, the anterior segment with aciculate gland spines swollen at the base. (3) The median lobes are much larger and more prominent. (4) The circumgenital glands are fewer. Average of a number of examples—median group 6, anterior laterals 17, posterior laterals 21. (5) Dorsal pores on the pygidium generally less numerous.

On *Diospyros* sp. (Ebenaceae), Sinoia, 16.xii.1927, Mazoe, 26.i.1928, Umvukwes, 16.vii.1928, Mtoroshanga Pass, 19.vii.1928, and Sinoia, 18.vii.1928. Found chiefly on the smaller branches, but specimens occasionally occur on the leaves; the male puparia are often found on the leaves.

This variety closely resembles *communis* var. *monotes*, from which it differs in the markedly different nature of the gland spines on the free abdominal segments. The median lobes are of similar form, but slightly larger, and the circumgenital glands are less numerous.

Fig. 5. Margin of free abdominal and basal pygidial segments, ×112, of: A, *Chionaspis* (*Pinnaspis*) *communis* var. *diospyros*, var. n.; C, *C.* (*P.*) *communis*, Hall; E, *C.* (*P.*) *communis* var. *monotes*, Hall.

Median lobes of adult ♀, ×225, of: B, *C.* (*P.*) *communis diospyros*; D, *C.* (*P.*) *communis*; F, *C.* (*P.*) *communis* var. *monotes*.

**Chionaspis (Pinnaspis) excisa,** sp. n. (fig. 6).

Puparium of the adult female pyriform to elongate pyriform, convex. Larval exuviae apparently dark bronze; they are really a very pale straw colour, but being transparent, the dark colour of the sublying female gives them a very much darker appearance than they really have. Nymphal exuviae pale straw colour shading into brown posteriorly. Exuviae covered by a thin film of secretionary matter which partially obscures the colour. The exuviae occupy rather less than half the total length of the puparium. Secretionary appendix white. Ventral scale thin and poorly developed; on removing the puparium a portion of the ventral scale remains attached to the dorsal scale anteriorly, but by far the greater portion remains attached to the host plant. Length, 1·25–1·5 mm.; breadth, 0·5–0·8 mm.

Male puparium of the normal form, non-carinated, with straw-coloured exuviae.

Adult female elongate oval; antennal tubercles minute with one and sometimes two stout curved bristles. A compact rounded group of about 8 parastigmatic glands

is associated with the anterior spiracles; the exact number is not easy to discern owing to the rounded nature of the group. Two marked series of aciculate gland spines run in from the margin to the vicinity of the anterior and posterior spiracles. Abdominal segmentation distinct. Free abdominal segments with aciculate gland spines of a similar nature to those occurring on the thorax; these are more numerous on the anterior segment than on the two posterior segments, and passing from the basal pygidial segments to the basal thoracic segment the spines become more swollen at the base. Abdominal segments, also, with numerous pores, supplied with short tubular spinnerets, marginally and an irregular line of pores at intervals extending right across the segments. Similar pores occur marginally of the thoracic segments, but are less numerous. Pygidium broadly rounded with median lobes large, prominent, and in close apposition; markedly serrate except on their outer edges. First lateral lobes small, but prominent and conspicuously dentiform. Other lobes wanting*. Between the median and lateral lobes is a conspicuous broad and deep

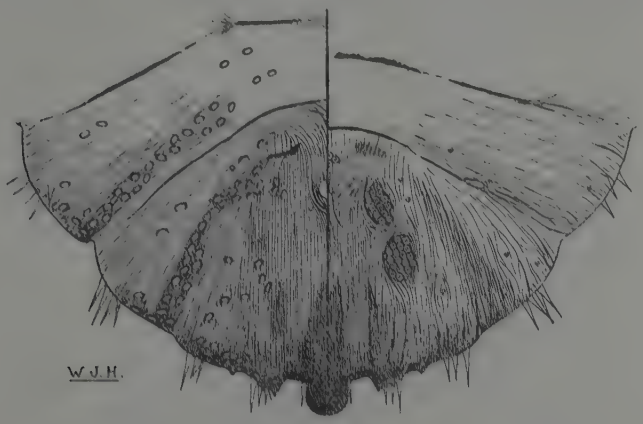



Fig. 6. *Chionaspis* (*Pinnaspis*) *excisa*, sp. n.: pygidium of adult ♀, ×225.

excision. A spiniform squama arises from the base of the outer edge of the median lobe on either side; this is not so long as the lobe. Just beyond the lateral lobes is a larger and much more conspicuous spiniform squama and usually one or two shorter ones. Beyond this are three groups of similar squamae, the basal group being composed of rather smaller squamae than the others. There may be from 1 to 5 squamae in each group, considerable variation occurring not only in number but also in size. Dorsal pores small, but surrounded by a chitinous ring that makes them appear larger and conspicuous. There are two well-defined interrupted series, but apart from these the pores are scattered and exhibit no regular arrangement. Circumgenital glands in five groups—median group 2–5, anterior laterals 10–16, posterior laterals 15–23; average of 17 examples 4 : 13 : 19. The groups are usually very compact. Anal orifice small and situated near the centre of the pygidium.

* In one abnormal specimen a 2nd pair of lateral lobes was well developed and highly chitinised, the lobe on the one side being larger than that on the other side of the pygidium. In both cases they were larger than the 1st lateral lobes, being elongate, more or less parallel-sided, finely serrated at the apex and falling away towards the outer edge. The bigger of the two had a conspicuous notch on the outer edge in addition. In the same specimen the circumgenital glands were also abnormal; median group 5, a single gland midway between the median and right anterior group which consisted of 11 glands, right posterior 7, left anterior 14, left posterior group 21.

On *Combretum* sp. (Combretaceae), Mazoe, 26.i.1928; on the under surface of the leaves lying along the veins in the angles between these and the body of the leaf.

This species is allied to *C.* (*P.*) *combreti*, Hall, from which it may be at once distinguished by the broad and deep excision on each side of the median lobes and the nature of the lateral lobes.

**Chionaspis** (**Pinnaspis**) **tuberculata,** sp. n. (fig. 7).

Puparium of the adult female elongate pyriform, narrowed in front and broadened posteriorly; convex. Larval exuviae semitranslucent, very pale brown at the posterior extremity; nymphal exuviae the same. The exuviae are about $\frac{2}{5}$ as long as the entire puparium. Secretionary appendix semitranslucent white, of the appearance of frosted glass, the colour of the sublying female being readily seen through. The colour of the living insect is a pale green; after death it turns dark brown, but much paler at the pygidium. Ventral scale very thin and delicate, remaining attached to the host plant; being semitranslucent, it is difficult to detect. Length, 1·25–1·5 mm.; breadth, 0·6–0·8 mm.

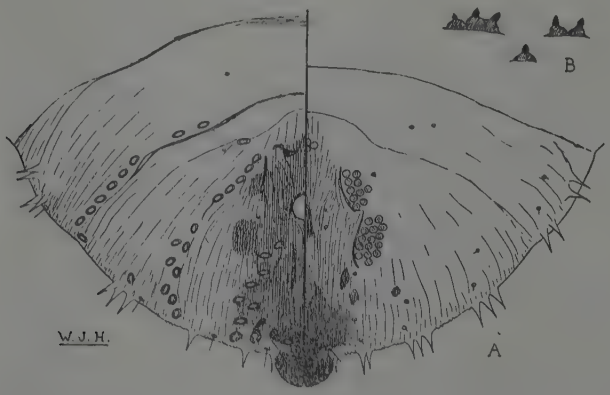



Fig. 7. *Chionaspis* (*Pinnaspis*) *tuberculata*, sp. n.: A, pygidium of adult ♀ 225; B, tubercles from venter of thorax, greatly magnified.

Male puparium of normal form with parallel sides; exuviae semitranslucent with the posterior half pale brown. Secretionary appendix whiter and less translucent than that of the adult female; faintly tricarinate.

Adult female elongate ovate. Antennal tubercles with usually one, but sometimes two, stout curved bristles. Anterior spiracles with 2–6 parastigmatic glands. Abdominal segmentation distinct. Margin of abdominal segments with scattered short tubular spinnerets and a few aciculate gland spines; these are also found on the thoracic segments, but the latter extend farther in from the margin. On the ventral dermis, situated on the thoracic segments and anterior free abdominal segments, are a few scattered tubercles carrying stout blunt spines. There seems to be no definite arrangement, although in a few specimens a pair on each segment, widely set apart, occurs. They are never found marginally of the posterior spiracles. The tubercles generally carry one or two spines; where two spines occur, there is a faint dividing line in the tubercle between them indicating that two tubercles have fused. In some cases the tubercles carry as many as seven spines, but where more than two are present they are relatively smaller. Pygidium broadly

rounded. Median lobes conspicuous, in close apposition, the outer edges forming a semicircle; serrated except at the extreme base of the outer edge where there is a marked constriction. Other lobes wanting. Squamae simple and relatively broad at the base; very delicate and often missing or folded back. There is always one arising from just beyond the median lobes and four groups between this and the base of the pygidium. The number of squamae in each group varies; the 1st group beyond the median lobes (excluding the one closely associated with the lobes) generally has one but may have two or even three; the 2nd usually has two, but often one or three. The number in the other groups is usually at least three and may be as many as six in the basal group. Dorsal pores relatively large, with short tubular spinnerets, in three well-defined interrupted series. Anal orifice situated near the centre of the pygidium. Circumgenital glands in five groups—median group 2–7, anterior laterals 7–14, posterior laterals 11–21; average of 20 examples 4 : 10 : 15.

On *Uapaca kirkiana* (Euphorbiaceae), Theydon, 17.iii.1928; on the under surface of the leaves.

Allied to *C.* (*P.*) *combreti* and *excisa* from both of which it can be easily distinguished by the nature of the female puparium, the presence of tubercles carrying spines on the venter of the thorax and free abdominal segments, the shape of the median lobes, and other characters.

**Chionaspis (Phenacaspis) subvisci,** sp. n. (fig. 8).

Puparium of the adult female of variable form, generally pyriform to elongate pyriform and convex. Larval exuviae yellow or golden, nymphal exuviae brown with a thin white secretionary covering film. The exuviae occupy rather more than

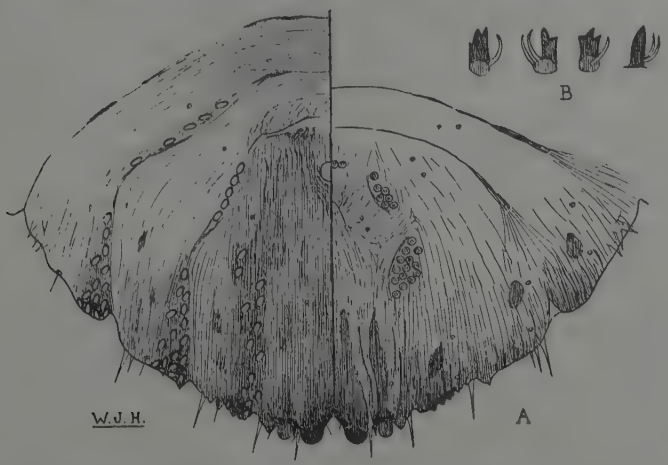



Fig. 8. *Chionaspis* (*Phenacaspis*) *subvisci*, sp. n.: A, pygidium of adult ♀, ×225; B, various forms of antennal tubercles, greatly magnified.

⅓ of the entire puparium. Secretionary appendix of a waxy appearance, smooth and shiny white; this is often masked by the incorporation of extraneous matter in its development. Ventral scale thin but usually remaining intact when the puparium is lifted. Length, 2 mm.; breadth, 0·8 mm.

Puparium of the male white with subparallel sides and pale brown exuviae; non-carinated. The shape of the puparium is often obscured by a dense mass of

short silky white filaments. The puparia tend to occur in groups, the whole of each group being covered by a mass of short white filaments.

Adult female narrowed anteriorly, broadest about the anterior free abdominal segment. Antennal tubercles produced into a conspicuous stout spinose projection of variable form, from the base of which arise one or two stout curved bristles. Anterior spiracles with a compact group of about 10 parastigmatic glands; from 1 to 3 similar glands are associated with the posterior spiracles. Abdominal segmentation distinct. Free segments with lateral marginal projections. Numerous pores with short tubular spinnerets occur marginally and a few aciculate gland spines. Both pores and gland spines occur on the thoracic segments, but are much less numerous except on the posterior segment. Pygidium broadly rounded. Median lobes set apart by a distance rather less than the width of one, broader than long and rounded at the apex. The median notch is V-shaped with a minute seta arising from either side and a conspicuous narrow chitinous band joining the bases of the lobes. First lateral lobes duplex, the inner lobule rounded and slightly longer than broad, the outer lobule slightly smaller and usually more pointed with a notch on the outer edge. Four spiniform squamae occur on either side, the last of these often having one or two smaller squamae associated with it, and on the basal segment there is a group of three or four much smaller squamae which are slightly swollen at the base, but to nothing like the same extent as those occurring on the free abdominal segments. Between the median and 1st lateral lobe is a very small but highly chitinised tooth-like projection. Dorsal pores in three well-marked interrupted series. The innermost series extends inwards from the margin in an irregular unbroken line on either side. The other two series consist each of two groups on either side, a marginal group in which the glands are numerous, and a group approximately midway between the margin and the median line in which the glands are arranged in a single row. Anal orifice small and situated nearer the base of the pygidium. Circumgenital glands in five groups—median group 3 or 4, anterior laterals 4–9, posterior laterals 11–17; average of 8 examples 3 : 7 : 14. Old adult females become highly chitinised with the exception of the pygidium and two posterior free abdominal segments.

On *Elaeodendron capense* (Celastraceae), Umtali, 10.vi.1928; the female puparia on the very small branches, and the male puparia on the leaves.

This species comes close to *c. visci*, Brain, from which it differs in the different shape and more conspicuous nature of the lateral lobes; the median notch is also different. The female puparium is rarely of the elongate form found in *visci*, nor is the male puparium carinated.

The individual selected as the type is an early adult female before the chitinisation of the tissues has set in.

I learn from Mr. Green that the limits of the subgenus *Phenacaspis* cannot be satisfactorily defined, but I have assigned this and the two following species to this subgenus for the present in view of the fact that the chitinous lining of the median notch in these cases is so clearly represented.

**Chionaspis** (**Phenacaspis**) **visci,** Brain (fig. 9).

*Phenacaspis visci*, Brain, Bull. Ent. Res., ix, 1919, p. 235.

On *Balanites* sp. (Zygophyllaceae), Umniati River, viii.1921, ex coll. Dept. of Agriculture, Salisbury.

Compared with authentic South African material and found to agree in all essential details.

**Chionaspis** (**Phenacaspis**) **visci** var. **umtalii,** var. n. (fig. 9).

This species differs from typical *visci* in the following respects: (1) The male puparia are non-carinated and, when fully developed, are obscured by a small

flocculent mass of white fibres. The female puparia are much the same as in *visci*. (2) The median lobes of the pygidium are very much larger. (3) Only a single pair of spines occurs between the median lobes, and not " two short plates and two short spines " as quoted for *visci*. (4) The spiniform squamae on the pygidium are longer and more conspicuous. (5) A single squama marginally of the basal pygidial segment is of quite a different form to the spiniform squamae, being much broadened basally. It is similar to the aciculate gland spines which occur on the two posterior free abdominal segments in very small numbers.

The circumgenital glands appear to be much the same as found in *visci*—median group 3–8, anterior laterals 5–13, posterior laterals 12–22 ; average of 20 examples 5 : 10 : 17.

On *Allophyllus* sp. (Sapindaceae), Christmas Pass, Umtali, 6.vi.1928 and 10.vi.1928 ; on the small branches and leaves.

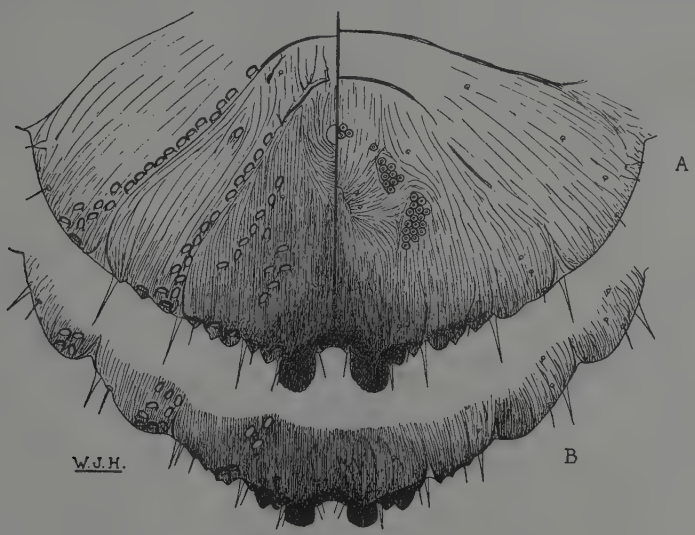



Fig. 9. Pygidium (pygidial fringe) of adult ♀, ×225, of : A, *Chionaspis* (*Phenacaspis*) *visci* var. *umtalii*, var. n. ; B, *C.* (*P.*) *visci*, Brain.

This has been compared with a little typical material of *C.* (*P.*) *visci*. The figure of the pygidial margin of *visci* given for comparison was drawn from a preparation made from this material.

**Chionaspis (Dinaspis) dentilobis,** Newst.

*Chionaspis dentilobis*, Newstead, Bull. Ent. Res., i, 1910, p. 195.

On " Mistletoe," Bulawayo Park, 9.x.1928.

I have a little authentic material of *dentilobis*, Newstead. The pygidial lobes in Rhodesian material are relatively somewhat smaller, but otherwise the characters appear in agreement. The absence of circumgenital glands places this species in the subgenus *Dinaspis*.

**Chionaspis (Dinaspis) gibber,** sp. n. (fig. 10).

Puparium of the adult female small and pyriform; so highly convex that it appears humpbacked. Larval exuviae golden brown; nymphal exuviae of a similar colour, the whole covered by a thin film of white secretionary matter which is often knocked off over the larval exuviae but remains intact over the nymphal exuviae and partially obscures the colour. In old examples the very highly convex nature of the secretionary appendix causes the exuviae to be very much tilted forward. Secretionary appendix white with faint transverse striations; delicate and easily broken. Ventral scale extremely thin and delicate, remaining adherent to the host plant. Length, 0·8–1 mm.; breadth, 0·5–0·6 mm.

Puparium of the male not seen.

Adult female pyriform. Antennal tubercles with one or two stout curved bristles. Anterior spiracles with 0–4 parastigmatic glands, usual number 1 or 2. Abdominal segmentation distinct. Each abdominal segment with a few pores marginally and a line of pores set at wide intervals which extend from the margin to about midway between the margin and the median line, the pores towards the median line being markedly smaller than those at the margin. The segments also carry a small group of aciculate gland spines. Similar pores and gland spines are found in the marginal region of the thoracic segments together with a few tubular spinnerets of a much

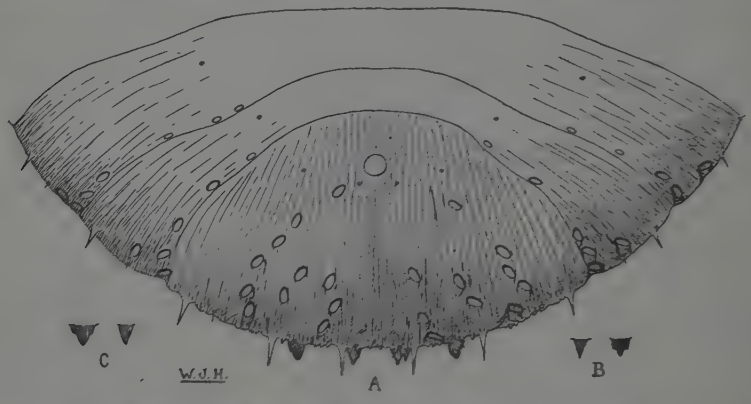



Fig. 10. *Chionaspis (Dinaspis) gibber*, sp. n.: A, pygidium of adult ♀; B, alternative forms of the median lobes; C, alternative forms of the lateral lobes. ×337.

smaller size. The pores on the abdominal segments are relatively few. Pygidium broadly rounded with two pairs of lobes. Median pair small, dentate, set apart by a distance approximately twice the width of one. The shape of the lobes is variable, but they are nearly always sharply pointed at the apex. Lateral lobes usually slightly larger than the median pair and also of variable form. Five simple and relatively small spiniform squamae on either side. Anal orifice set near the middle of the pygidium. Dorsal pores few in number, but large and conspicuous; at least three interrupted series can be detected. In the two series nearest the base of the pygidium, the one or two glands nearest the median line are markedly smaller than the rest. The dorsal pores are slightly larger than those occurring at the margin of the abdominal segments. Circumgenital glands wanting.

On an unknown shrub, Darwendale, 28.xi.1928; the small branches were heavily encrusted with the puparia.

This species falls into the group of *dentilobis*, *auratilis*, *tenuidisculus*, and *capensis* of Newstead, and *amaniensis*, Lind., from all of which it appears to be distinct. The extraordinary humpbacked nature of the female puparia, the relatively small number of dorsal pores on the pygidium and their large size are characteristic.

The tissues of the adult female are extremely delicate, and it was difficult to get a satisfactory preparation of a fully developed individual. The specimen selected for the type is an early adult female.

**Chionaspis (Dinaspis) lounsburyi,** Leon.

*Dinaspis lounsburyi*, Leonardi, Boll. R. Sc. Agric. Portici, 1914, p. 216.

*Dinaspis lounsburyi*, Brain, Bull. Ent. Res., x, 1920, p. 101.

On *Gymnosporia* sp. (Celastraceae), Embeza, 10.iii.1928, and a Celastraceous plant, Umtali, 20.xi.1928.

This has been compared with some typical South African material and found to be identical.

Professor Brain, when recording this species from South Africa (*l.c.*), sinks *capensis*, Newstead, as a synonym of *lounsburyi*. Unfortunately I have not Leonardi's original description, but *capensis* as figured and described by Newstead differs from *lounsburyi* as described by Brain in the nature of the median lobes. In *capensis* they are said to be "rudimentary, widely separate, duplex and dentate." A long series of preparations from both Rhodesian and South African material have been examined, and in no case are the lobes duplex or of the same form at all as found in *lounsburyi*. Undoubtedly *capensis* and *lounsburyi* are very closely allied, but I am not quite satisfied that they are synonymous without examining either the type or typical material of *capensis*.

Brain records this species (*l.c.*) from Umtali; I have also collected it at Umtali and at Embeza which is about 10 miles from Umtali.

**Chionaspis (Dinaspis) pittospori,** sp. n. (fig. 11).

Puparium of the adult female elongate, narrowed in front and broadening posteriorly; highly convex. Larval exuviae pale brown, golden brown or reddish brown; nymphal exuviae pinkish or reddish brown. Nymphal exuviae with a thin covering of white secretionary matter which partly obscures the colour. The exuviae occupy slightly less than half the length of the entire puparium. Secretionary appendix white with minute transverse striations. Ventral scale moderately well developed, particularly at the margin, but generally remaining adherent to the host plant. Length, 1·5–2 mm.; breadth, 0·4–0·6 mm.

Male puparia not seen.

Adult female elongate, but much narrowed anteriorly. Antennal tubercles with two curved bristles of usually unequal size. Anterior spiracles with a compact rounded group of parastigmatic glands containing 4–8 glands; posterior spiracles with 0–3 similar glands. Abdominal segmentation discernible. Free abdominal segments with short tubular spinnerets and a group of aciculate gland spines in the vicinity of the margin. There are a few similar pores marginally of the thoracic segments, and a few spinnerets of a minute size, but very few gland spines and those in the neighbourhood of the posterior spiracles—none associated with the anterior spiracles. Pygidium broadly rounded. Median lobes small, rounded and slightly divergent; very widely set apart; 1st lateral lobes larger than the median lobes and rounded. Other lobes wanting. Five simple squamae occur on either side, and between the median lobes there are two minute but stout spines. Dorsal pores relatively large with short tubular spinnerets in three interrupted series, the innermost series being represented by two or three pores at the margin and two to four set well back from the margin. Anal orifice large, appearing larger than it really is owing to

the folding of the extremely delicate cuticle surrounding it, directed towards the base of the pygidium. Circumgenital glands absent.

Old adult females become distorted in the region of the thorax and the anterior free abdominal segments.

On *Capura nitida* Impatiaceae, Umtali, 21.ix.1927 and Ranker, 16.vii.1928, and *Pittosporum viridiflorum* Meare, 4.x.1927; on the leaves and young stems. In the material collected on *Capura* the puparia were often ranged round the periphery of the upper surface of the leaf; they occur on both sides of the leaf but appear to favour the upper surface.

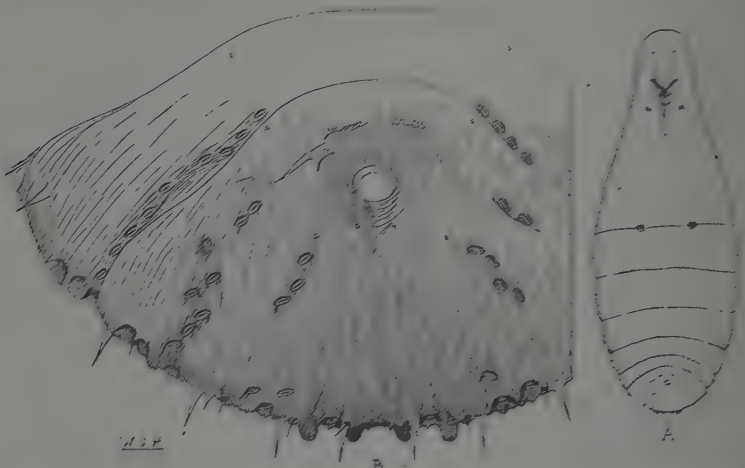


*Fig. 11. Chionaspis (Pinaspis) pittospori*, sp. n.: A, the adult ♀, ×40; B, pygidium of adult ♀, ×304.

This species is allied to *Dinaspis auratiis*, *tenuidisculus*, *capensis* and *dentilobis* of Newstead, and *amaniensis*, Lind. A comparison of the characters will, however, serve to separate it at once from any one of these.

**Chionaspis (Poliaspis) kiggelariae** var. **allophylli,** var. n. (fig. 12).

Differs from typical *kiggelariae*, Brain (Bull. Ent. Res., ix, 1919, p. 238), in the following characters: (1) It is smaller. The puparium of the adult female has a length of 1·8–2 mm., and breadth, 0·7–0·9 mm. (2) The antennal tubercles carry two stout curved bristles. (3) There is no marked chitinisation of the tissues of the anterior portion of the body. (4) The ventral thoracic dermis between the spiracles is markedly imbricated. (5) The aciculate gland spines, at the base of the pygidium and on the last two free abdominal segments, are much larger. (6) The duplication, and larger size, of the squamae on the pygidium. (7) The relatively somewhat greater number of the dorsal pores. (8) The presence of 10 groups of circumgenital glands. The inner series consists of median group 2–6, anterior laterals 8–15, posterior laterals 16–39; average of 14 examples 5 : 12 : 31. The outer series consists of median group 1–3, anterior laterals 0–6, posterior laterals 0–5; average of 14 examples 2 : 4 : 2.

On *Allophyllus* sp. (Sapindaceae), Umtali, 10.vi.1928. Female puparia chiefly on the small branches with an occasional individual on the upper surface of the leaves; male puparia almost invariably on the upper surface of the leaves.

This has been compared with authentic material of *kiggelariae*. It is obviously closely allied to this species, but the differences are sufficiently great and consistent to enable them to be easily separated.

The tendency for the abdominal tissues to contract in the process of preparation makes it difficult to obtain fully satisfactory examples for examination.

**Lepidosaphes beckii,** Newman.

*Coccus beckii*, Newman, The Entom., iv, 1869, p. 217.

On *Citrus aurantium* (Rutaceae), Municipal Park, Umtali, 9.vi.1928, and the Premier Estate, Umtali, 27.viii.1928.

I had been informed that this species occured at Umtali, but had previously not collected it myself. It appears, so far as is known at present, to be confined to the

Fig. 12. *Chionaspis* (*Poliaspis*) *kiggelariae* var. *allophylli*, var. n.: pygidium of adult ♀, ×225.

Umtali district where the climatic conditions are different from those met with further inland. There is a tendency for this species to favour coastal conditions, and although Umtali is some 100 miles inland, there is a distinct coastal touch in its climatic conditions.

**Lepidosaphes distincta,** sp. n. (fig. 13).

Puparium of the adult female very elongate and narrow, broadening only very slightly posteriorly. Larval exuviae elongate with sides subparallel and rounded at either extremity; dark purplish brown. Nymphal exuviae much the same colour as the larval exuviae but sometimes paler, always purplish brown at the posterior extremity and covered by a film of secretionary matter which completely obscures the colour. This film, like the secretionary appendix, is dirty white almost dull brown, due to the incorporation of foreign matter. The secretionary film over the larval exuviae is very thin and generally wanting. The exuviae occupy about $\frac{1}{3}$ of the fully developed puparium. Ventral scale very poorly developed, remaining attached to the host plant as an obscure semitransparent white film. Length, 2–2·25 mm.; breadth, 0·4–0·5 mm.

Male puparium the same shape as the female puparium, but smaller. Exuviae dark reddish brown.

Adult female very elongate with sides subparallel. Antennal tubercles minute, carrying three or four small curved bristles. Anterior spiracles with one or two, generally two, parastigmatic glands. Thoracic region very much attenuated, the entire dermis being faintly, but quite clearly, closely striated transversely. These transverse striations extend on to the free abdominal segments, but gradually become more and more obscure. Free abdominal segmentation not very clearly marked. Marginal region of the segments with a few small pores supplied with short tubular spinnerets and a group of small aciculate gland spines. The pores and gland spines occur on the posterior thoracic segment also, but are not found anterior of this. Pygidium triangular. Median lobes conspicuously tridentate with a small dentiform process between. Owing to the dense chitinisation of the tissues, it is impossible to make out whether this is of a glandular nature or not.

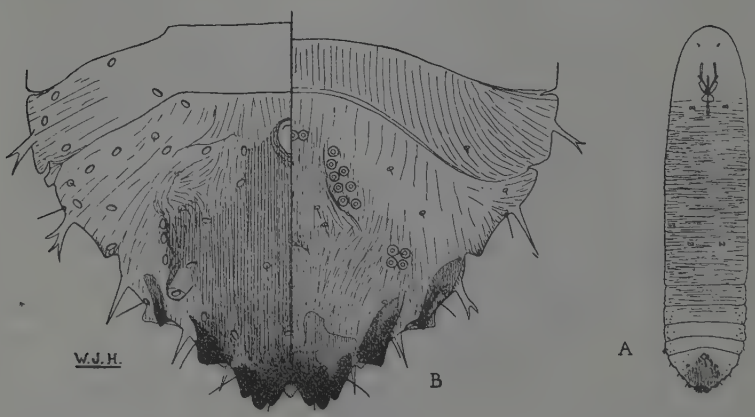



Fig. 13. *Lepidosaphes distincta*, sp. n.: A, the adult ♀, ×45; B, pygidium of adult ♀, ×350.

First lateral lobes dentate, but smaller than the median lobes, 2nd lateral lobes of similar shape, but smaller than the 1st. All lobes very densely chitinised, the chitinisation continuing within the margin. There are five squamae on either side; that between the median and 1st lateral lobes is small, rather inconspicuous and not infrequently difficult to detect; that between the 1st and 2nd lateral lobes is usually spiniform, but may be slightly frayed near the apex; the remaining three are of very variable form, sometimes spiniform, but more generally divided at the apex into 2, 3, or 4 spines. Dorsal pores few, small and scattered. Circumgenital glands in five groups—median group 2–4, anterior laterals 6–12, posterior laterals 2–4; average of 10 examples 3 : 8 : 4. Anal orifice situated near the base of the pygidium.

The excessively dense chitinisation of the lobes and margin of the pygidium in their vicinity appears to result in this portion becoming upturned, and it is not easy to get a preparation which shows the outline of the pygidium satisfactorily.

On *Zizyphus jujuba* (Rhamnaceae), Mazoe, 18.i.1928; on the small branches.

This is a remarkable species and quite unlike any other of the genus *Lepidosaphes* known to me.

# EXPERIMENTS IN GRASS FIRES AGAINST *GLOSSINA MORSITANS* IN SOUTHERN RHODESIA.

By J. K. Chorley.

CONTENTS.


| | | PAGE |
|---|---|---|
| 1. | Introduction ... ... ... ... ... ... | 377 |
| 2. | Description of Area ... ... ... ... ... | 378 |
| 3. | Organisation of Fire ... ... ... ... ... | 378 |
| 4. | Game Present in Area ... ... ... ... ... | 378 |
| 5. | Types of Forest Found in the Area ... ... ... | 379 |
| 6. | Effect of the Fire upon the Forest ... ... ... | 380 |
| 7. | Effect of the Fire upon Puparia Collected ... ... | 380 |
| 8. | Density of Fly in the Area ... ... ... ... | 381 |
| 9. | General Effect of the Fire upon the Adult Flies ... | 382 |
| 10. | Collection of Puparia and Seasonal Activity ... | 383 |
| 11. | Pupal Period ... ... ... ... ... ... | 383 |
| 12. | Parasites ... ... ... ... ... ... | 384 |
| 13. | Source of Food of the Flies ... ... ... ... | 385 |
| 14. | Summary ... ... ... ... ... ... | 385 |


## 1. Introduction.

Several investigators have advocated the use of late organised grass fires as a method of controlling tsetse-flies in various parts of Africa. Swynnerton[1] strongly recommended the use of fires for combating three different species of tsette-fly in Portuguese East Africa. The same investigator has used fires extensively in his reclamation work in Tanganyika Territory against both *Glossina morsitans* and *G. swynnertoni*. In N. Nigeria, Lloyd[2] and his collaborators state that a deferred grass fire, in 1925–1926, "resulted in a considerable reduction in the numbers of *G. morsitans* and probably a large destruction of their pupae."

In Southern Rhodesia most of the fly areas are situated in mopane forest country. On the whole, the grass found in these mopane belts is short and sparse and veldt fires are not fierce. The *Brachystegia-Berlinia* forest on the middle veldt in the Lomagundi District carries more grass, and it was decided to carry out these investigations in the fly-belt there. The area selected is judged to be fairly representative of much fly-infested *Brachystegia-Berlinia* forest in the Colony.

The results of two investigations carried out in the dry seasons of 1927 and 1928 are given in this paper.

The main point of the investigation was to observe, and record, the direct effect of an organised veldt fire upon (*a*) the adult fly, and (*b*) the puparia. The indirect effect of the fire upon the forest, and game, in so far as it might affect the habitat of the fly and its food supply, was also noted. A survey of the trypanosome infection of the flies in the area was also undertaken.

The preliminary observations in each season extended over several months previous to the fires.

This account is a progress report and not a final pronouncement upon the efficacy of veldt fires as a method of controlling *G. morsitans* in Southern Rhodesia.

## 2. Description of Area.

The area chosen is situated in the Lomagundi fly-belt about seventy miles from the railhead at Sinoia. It lies eight miles north of the zone fenced in 1925 and on the watershed, midway between the Angwa and Hunyani Rivers, the site of the camp being about eight miles N.W. of Doma Hill. The altitude is between 3,500 and 3,800 feet. Several small streams traverse, or rise in, the area. One of them, the Rakute River, retains a good supply of water throughout the dry season, and drinking holes occur on the Chapingabadza, a small tributary of the Rakute. Another, the Winde, retains good supplies of water at its source but poorer supplies lower down. Both these streams flow north through the area. A number of very small tributaries of the Winde, namely, the Chamba, Binge, and Bange, all contained water in pools or mud holes until December. Several small native kraals were dotted about the area along the small water courses.

The soil is granite sandveldt, the country gently undulating with rocky outcrops of granite on the dividing ridges. Fairly large heavy grass vleis occur on the Chapingabadza, on the Winde, and at Cha-uka Hill. Cha-uka Hill was more or less in the centre of the area worked. The camp was built on the Chamba about a mile from Cha-uka Hill. For a number of years past this locality has been known to be heavily infested with fly and well stocked with game. A survey made in 1924 indicated Cha-uka Hill as the most heavily infested centre in the area.

## 3. Organisation of Fire.

The burn was arranged to take place at the end of September. It is difficult to preserve grass in Southern Rhodesia after, or even as late as, this date owing to the presence of prospectors and the hunting proclivities of the natives. Honey-gathering natives are also difficult to control. By the end of September, in a good year, most of the grass is thoroughly dry and in a condition to burn cleanly and fiercely. The prevailing wind is easterly or north-easterly.

In 1927 thirty boys were employed and probably an equal number of local natives of both sexes. Fifteen of these boys were spread on the north side on a four mile front and fifteen boys on a six mile front along the Rakute River on the eastern side, and the fire started when a signal fire was lit on the top of Cha-uka Hill. The fires were started up simultaneously, a good strong wind arose and the fire swept across the area "according to plan." It is doubtful if a cleaner or more thorough burn could be obtained.

In 1928 over sixty boys were employed and about twenty local natives, men and women. Fifteen native hunters with rifles were distributed along the line. The natives were spread as before and the fire started by the same signal. For two hours the fires burnt well, and then the wind, which had been blowing strongly at first from the north-east, became variable, and sometimes failed altogether.

## 4. Game Present in Area.

For many years this area has been well known as a game centre. The species of game found include eland, sable, kudu, roan, waterbuck, zebra, tsessebe, reedbuck, duiker, steenbok, Sharpe's steenbok, and oribi. Warthog and bushpig are also common. Troops of guinea fowl were to be found along most of the streams.

In 1927, before the fire, it was difficult to judge how much game was present in the area, but certainly a considerable amount. After the fire, green grass began to spring up on all the vleis, particularly on the large ones around Cha-uka Hill and on the Chapingabadza River, while a few early showers in October brought on the grass in the valleys generally. The game was now easy to locate and included numerous

large herds of eland and zebra (running together) up to 300–400 strong. Most of the eland came into the area after the fire. It is considered that the smaller buck were present in the area throughout, but it was only after the fire that it was realised how many were in the area. Reedbuck and oribi were particularly abundant on the vleis after the fire. It should be mentioned that the area was maintained as a temporary Game Reserve from 1925 to 1928.

In June 1928, a dozen native hunters were placed north of the old north fence, in order to drive out most of the game before the erection of a new game fence, running roughly parallel to the fences built in 1925 and north of Cha-uka Hill. Thus practically the whole of the area worked now lies inside the new fenced zone. Although several hundred buck were shot out before the fire, there was still a considerable quantity of game inside the area under observation up to the end of November, as little shooting occurred close to camp. The herds of eland and zebra seen in 1928 were not so large as those seen in 1927, though the number of small buck, pig and duiker was about the same.

It is not thought that the disturbance of the game, owing to the shooting operations, had had any effect on the "fly" before these observations were concluded.

### 5. Types of Forest Found in the Area.

The dominant forest over the whole of the area is a mixed *Brachystegia-Berlinia* bush. The ridges are clothed mainly with "mfuti", a *Brachystegia* usually found in this area on a poor type of soil, sometimes rubble, with a low water table. Scattered small clumps of practically pure *Uapaca kirkiana* are found. On the rocky outcrops "Mountain Acacia" (*Brachystegia tamarindoides*), *Cussonia* sp., and small aloes replace the "mfuti." In the valleys, on deeper soil with subsoil moisture, "msassa" (*Brachystegia randii*), and "mnondo" (*Berlinia globiflora*) predominate.

Along the edge of vleis, *Faurea saligna*, *F. speciosa*, and *Acacia* spp. are common. Other associated species found throughout the bush are numerous and include *Afromosia angolensis*, *Pseudolachnostylus* spp., *Combretum* spp., *Afzelia cuanzensis* (Pod mahogany), *Terminalia* spp., *Pterocarpus*, *Monotes africanus*, *Parinarium mobola*, *Diplorhynchus*, *Diospyros mashuma* and *Diospyros* sp., *Ficus* sp., *Bauhinia* spp., etc.

The stream-bank forest consists mainly of evergreens, but is not the heavy type of stream-bank forest associated with the big rivers. The chief species consisted of *Diospyros* spp., *Eugenia* spp., *Salix* spp., and *Mimusops*.

On termite mounds small thickets of *Diospyros*, *Bauhinia*, *Grewia*, and *Ficus* are usual. The vegetation generally consists, however, of open savannah forests in which thickets are few and of small extent.

In the vleis a small *Protea* is common. The vleis are exceptionally well grassed but generally speaking the grass throughout the *Brachystegia-Berlinia* bush was fair to poor. The lower areas of "msassa" carried on the whole a heavier grass than the "mfuti."

A better carpet of grass covered the area in 1927 than in 1928, most probably due to the succession of two poor rainy seasons culminating in 1927–28.

Leaf-fall became fairly general in the "mfuti" bush on the ridges towards the end of July, and was complete by the end of August. These "mfuti" covered ridges remained bare of leaf until December. Leaf-fall in the lower lying "msassa" bush commenced in July and was complete in August. By the end of September most of it had just commenced to flush into new leaf. At the date of the fire at the end of

September, 1928, there was a very clear demarcation between the leafless "mfuti" covered ridges and the lower lying "msassa" in practically full leaf. This was particularly noticeable along the valleys of the Chamba, Winde and Rakute.

The "msassa" flushed into leaf about three weeks earlier in 1928 than in 1927.

### 6. Effect of the Fire upon the Forest.

In 1927 the fire was a particularly successful clean burn, sweeping right through the bush. The only parts not burnt out were the areas of coarse green grass, or cane, along the stream banks or in places where the banks were covered with evergreen, *Eugenia*, *Diospyros* or *Ficus*, etc. The effect on the "msassa" where the grass was heaviest was to scorch the new leaves, particularly the lower ones. These died and dropped but were replaced within a month or six weeks. In the lighter grassed areas only the lower leaves were scorched, and within a month few signs of the burn could be noticed on the trees.

In 1928 the fire was not nearly as clean or fierce as in 1927, due chiefly to the wind dropping and becoming variable in the afternoon and to the poor grass present in large areas of the "mfuti" bush. These poorly burnt areas were burnt off by special gangs of boys employed for several days immediately succeeding the fire. More than half the area was, however, burnt off very thoroughly; it was only the western and north-western side of the area burnt off in the afternoon which burnt poorly. This area included the Winde River, where fairly big areas of "msassa" bush were not affected by the first day's burn.

As in 1927 the passing of the fire scorched the lower leaves of the "msassa" in the lower lying areas and these were replaced within six weeks. Where the trees were only commencing to flush, little effect was noticeable soon after the fire. In the "mfuti" bush the fire caused the few remaining dead leaves to fall and left the forest completely bare.

In the big vleis around Cha-uka the fires were exceptionally fierce but the small *Protea* bush commenced to flush into leaf very soon afterwards.

It is not considered that in this area annual fires would have the effect of checking the spread of the *Brachystegia-Berlinia* forest or of so altering the forest types as to make them unsuitable to the tsetse-fly. There is not sufficient grass or undergrowth to cause a really fierce fire in the bushed areas. Further, the fly is able to find sufficient shade within the burnt areas to maintain itself. The main point appears to be that the period of complete leaf-fall of this type of forest is not long enough to cause a serious check on the development of the fly, owing to the "msassa" (*Brachystegia randii*) flushing into leaf immediately after leaf-fall, if sufficient underground water is available.

### 7. Effect of the Fire upon Puparia Collected.

Table I shows the number of puparia collected each week in the area and the percentage of puparia which failed to yield either flies or parasites.

In 1927, the figures for the week (actually only three days) preceding the fire is not considered to be a fair average as less than one hundred puparia were collected. It is, therefore, eliminated.

The effects of the fire on collected puparia should show most in the first week's collection, afterwards the effect would be diminishing, owing to the collection of freshly deposited puparia.

The following figures show the percentage increase or decrease in *dead* puparia obtained :—

| | 1927. | | 1928. | |
|---|---|---|---|---|
| First week after fire ... ... | plus | 6·4% | ... minus | 1·8% |
| Average of 2 weeks ... ... | plus | 18·0% | ... plus | 6·8% |
| Average of 4 weeks ... ... | plus | 10·5% | ... plus | 21·3% |

A slight rise was thus recorded, in the first week, in 1927 and a fall in 1928. These two figures are the most reliable index of the actual immediate effect of the fire. The rise and fall is too small to be considered, as it is no more than the average weekly difference over the period. From this it would appear that the fire had no effect whatsoever on the puparia.

In addition, the effects of two early burns, one in August, 1927, and another in July, 1928, have to be considered. In a small early burnt area in 1927 a rise of 17 per cent. in dead puparia was recorded (average of three weeks) followed by a fall to what may be considered normal ; and in July, 1928, a rise of 8 per cent. which, however, was followed by an even higher figure on the unburnt area. Thus the deviations are not large enough upon which to base any conclusions. Also the number collected was too small to give a reliable figure.

The averages for the months of October and November both in 1927 and 1928 are, however, considerably above the averages for the colder months. This, in the opinion of the writer, is not attributable to the fire. The same increase in dead puparia collected during October and November was noticed first in 1922, and again in 1923, during work carried out in the Umniati fly-belt, and it is considered to be mainly due to the lethal effects of exposure to the hot summer sun. Experiments carried out at that time showed that half an hour's exposure to a temperature of 118° F. was sufficient to kill the puparia. An anomaly occurs in the figure obtained in the third week of October, 1927, when the percentage of dead puparia was very low (36·4) comparable with the "normal" obtained before the burns, and it is difficult to explain. Unfortunately there was no control area, as the fires covered a very large area, either on the first day or on subsequent days.

These collections of puparia do not, of course, contain individuals that would be totally destroyed during the fire when most of the old dry logs were consumed. How many were destroyed in that manner is difficult to estimate, but the figures show that probably 95 per cent. of all deposited puparia are not destroyed or killed by the fire, or the collections would have fallen considerably immediately following the fire, and the percentage of dead ones have risen markedly.

This is one of the principal facts that has emerged as a result of these investigations.

### 8. Density of Fly in the Area.

Regular comparable density counts were made in three localities every fourteen days or so. The results are shown in Table 2.

The area along the Winde River is a typical dry season habitat of the fly in this area. "Msassa" (*Brachystegia randii*) and *Berlinia globiflora* are the dominant forest trees, for perhaps a quarter to half a mile on each side of the stream. Along the stream bank are numerous evergreen trees or bushes, giving shade, while water in pools was present all the year, and game, principally warthog, frequented the area. Small vleis with green grass are common. In 1928 the male density was highest in July, and it remained fairly steady, around 20, until the end of September, The immediate effect of the fire was, more or less, to concentrate the fly along the river. A count made the day after the fire showed a considerable rise in both

density and activity (i.e., males plus females), and also in the female percentage. This rise was maintained more or less until December; in fact the heaviest density recorded (80), and the highest activity (72), was found here in the middle of November. Within a few days of the fire, the heavy concentration close to the river was not particularly noticeable, as the fly was scattered generally throughout the "msassa" bush, at that time practically in full leaf (new season's foliage). When the first density count was made, in 1928, fires were actually burning in the area.

Generally speaking, the same concentration of fly was noticed in 1927, and the same spread occurred after the fire, as soon as the "msassa" flushed into full leaf. The ridge of hills, of which Cha-uka is the highest point, forms a horseshoe. The amphitheatre enclosed constitutes an extremely favourable habitat for the fly until leaf fall becomes general in September. During November, when the "mfuti" bush is bare, hardly a fly can be found inside the horseshoe itself, though there is a fair concentration of fly close to the Winde River, which runs at the foot of Cha-uka Hill. The density of fly in both years commenced to fall in this area before the fire. In 1927 the fire around Cha-uka was particularly good, the density of fly, however, showed little movement and remained consistently low (below 15). The area was actually becoming unsuitable to fly before the burn.

In 1928, the density of fly remained fairly steady (about 22) until the middle of September, when leaf-fall became general, and the density dropped to eight. The fire was not a good one in the horseshoe or along the Winde River, and a fair concentration of fly occurred. The effect of this concentration was noticeable for about one month, not in the horseshoe itself but in the "msassa" bush nearer the Winde River. By November the density had fallen below 10. The presence of new native kraals in the horseshoe and the breaking up of the native gardens interfered somewhat with the free ranging of the big game, but pig and warthog were numerous in the area.

The third area employed as a test area consisted of typical "mfuti" bush on the ridges. Leaf fall became general in August, and the ridges were practically bare by the middle of September and remained bare until the rains. The density of fly began to fall before the fire and remained low after the fire. There was no concentration of fly but a continued drop from August onwards. (*Note.*—The density count made the day before the fire in 1928 is not a reliable one as the day was cold and overcast with slight rain.)

The figures shown do not indicate this progressive decline as clearly as is desirable, the reason being that the collecting party had to cross the Chamba River before getting into the "mfuti" bush on the ridges, and always a number of following flies were collected. Field notes show that in some cases practically all the fly were caught in the first fifteen minutes and few afterwards. If collected over a period of two or more hours, the density shown would be halved or quartered.

### 9. General Effect of the Fire upon the Adult Fly.

The general effect of the fire was to accelerate the apparent concentration of the fly, which was already in progress before the fire, owing to the general leaf-fall of the deciduous forest. This apparent concentration took place along the small streams in the area, where evergreen trees afforded sufficient shade for the fly. After the fire the fly spread (in 1928) throughout the "msassa" bush, which had flushed into leaf shortly before the fire. The concentrations are not heavy; in fact they seem to be the residue of normal colonies, since the density after the fires did not rise abnormally and was only slightly higher than before the fire.

It is not considered that the actual passing of the fire killed many adult flies. In 1928 the density of fly recorded before the fire, in the three test areas, was roughly

half the density recorded in 1927. This decrease may, or may not, be attributable to the fire in 1927, no suitable control area being available for comparison.

(N.B.—All flies bred out in the Laboratory were released in the area in order not to interfere with the natural conditions.)

## 10. Collection of Puparia and Seasonal Activity.

Between twelve to fifteen natives were employed collecting puparia, and an endeavour was made to collect at least 300 puparia each week. From the middle of October, however, this was not possible owing to the scarcity of fly in the area. The following number of puparia were collected during these investigations :—

| | *Apparently live Puparia.* | *Empty Cases.* | *Parasitised Cases.* |
|---|---|---|---|
| 1927 | 5,208 | 74,644 | 756 |
| 1928 | 6,541 | 93,342 | 958 |

During June, July and August, the collections were made generally throughout the bush, both in the "mfuti" forest as well as the "msassa." Particularly heavy collections were made at this time around Cha-uka Hill and inside the horseshoe of hills. As the leaf-fall became general, the collections were made along the Winde and Rakute Rivers and their small tributaries. In October and November it was useless to put the boys on working in the leafless " mufti " bush. The collections were made under overhanging rocks close to the river, in the river bed, and generally throughout the bush wherever there was sufficient forest shade and suitable breeding sites.

In 1927 many of the puparia were found under suitable fallen logs, but most of these were burnt during the fire in that year or rotted owing to continual handling and termites. In 1928, most of the puparia were found under shady rocks close to the hills, particularly during the first few months, and at the base of trees, etc., and afterwards under rocks, at the base of trees, occasionally in ant-bear holes, etc., mainly in the " msassa " bush or along the rivers. No heavy deposits of puparia were located, and as a matter of fact no very heavy concentrations of fly were found. (A density of eighty upwards would be considered heavy.) The number of puparia found in each site varied from one to five, the majority sheltering less than three.

The number of puparia collected which shewed the exit hole of small parasites, most probably *Syntomosphyrum glossinae*, was the same in 1927 as in 1928, namely, 1 per cent. of total empty cases. This is the same as the number actually bred out. The proportion of apparently live puparia to empty cases collected in 1928 rose from 8 per cent. in June to 10 per cent. in August and then dropped to 4 per cent. in October and November (see Table 3). The figures for the two years agree closely. The small proportion of live puparia collected from October onwards coincides with the shorter pupal period. The greatest number of empty cases was collected in October of each year, and this coincides reasonably closely with the period of greatest activity of the adult in September.

## 11. Pupal Period.

The maximum pupal period as obtained from collected puparia is shown in Table 4. These are calculated from the first day of the week of collection to the date on which the last fly emerged. It is not a very accurate method of calculating the pupal period, but is sufficiently approximate. It is assumed that in each week's collection at least one newly deposited puparia is present.

It will be seen that in 1927 the pupal period was sixty-one days for puparia collected in August, falling to a minimum of thirty-two days for puparia collected in

November. The mean temperature over this period rose from 58° F. in August, to 76° F. in November. In 1928, the maximum pupal period was eighty-two days for puparia collected in June, falling to a minimum of twenty-one days for puparia collected in November. The mean temperature over this period rose from 56° F. in June to 78° F. in November.

It is interesting to note that the maximum pupal period recorded at this altitude is twelve days longer than the maximum recorded in June, from collections made at a very much lower altitude in the Umniati fly-belt in 1922–23.

The minimum pupal period in 1927 was eleven days longer than in the Umniati belt ; in 1928 there was no difference. It is unfortunate that comparable temperature records are not available, on the whole, though the mean monthly temperature in the Umniati Valley would be 3° F. to 4° F. higher than in the Lomagundi area.

## 12. Parasites.

A. *Insects.*—Three species of insect parasites were bred out in the area, namely, a Bombyliid fly, *Thyridanthrax* sp., and two Hymenoptera, viz. : *Syntomosphyrum glossinae* and *Stomatoceras exaratum.*

In 1927, twenty-eight Bombyliids emerged or were found in dissection ; five puparia gave *Syntomosphyrum* (about twenty in each) and one *Stomatoceras exaratum.* They amounted to 1·2 per cent. of emergences. During 1928, twenty-nine Bombyliids were obtained, either as adults, or as larva on dissection, and three *Syntomosphyrum glossinae.* In this year they amounted to 1·05 per cent. of emergences. The majority emerged during October and November, but never exceeded 2 per cent. of emergences in any week.

There is a very marked difference between the number of parasites obtained in this area, and the number found in the Umniati fly-belt. In that belt, 23 per cent. of parasites were obtained over a similar period, while in the month of November over 84 per cent. of parasites were obtained. The absence of the parasite, *Mutilla glossinae,* from this area is of interest.

B. *Trypanosome Infection.*—A working estimate of the trypanosome infection of the fly in the area was also made. For this purpose the area was treated as a single unit. The trypanosomes were placed into their respective groups on their morphology and their position in the fly, by the method employed by Lloyd and Johnson[4] in Northern Nigeria. It has not been possible to identify specifically the various trypanosomes present in the area by the usual laboratory methods, as no laboratory animals were employed.

In 1927, 618 flies were dissected, and 905 in 1928. Permanent stained mounts were made of all infected parts and re-examined at subsequent times. Batches of fifteen to twenty flies were dissected at a time. When large batches were brought in, it was found that many of the older flies died before they could be examined, while the young, and therefore uninfected, flies survived. Thus, in the hot weather, it was found that dissections made late in the afternoon, from a batch of flies made early in the morning, contained fewer infected flies than dissections made in the morning. The catches were, therefore, regulated so that all the flies caught could be examined.

Pathological trypanosomes of the three tsetse-borne groups were found in the area, namely :—

(*a*) *T. congolense* group developing in the gut, labrum and hypopharynx.

(*b*) *T. vivax* group developing in the labrum and hypopharynx.

(*c*) *T. brucei* group developing in the gut, gland and hypopharynx.

In 1927, 10 per cent. of the flies contained mature infections during the months of August, September, October and November (see Table 5). In 1928 the percentage of mature infections rose from 9 per cent. in July to 15 per cent. in October. The average mature infection of all groups over the two years is approximately 11 per cent.

Only one case of *T. brucei* infection was found, though this organism was found in blood smears taken from two native-owned dogs in the area. An analysis of the mature infection shows that in 1927 thirty flies, or 4·8 per cent., were infected with *T. congolense*, and thirty-three flies, or 5·3 per cent., with *T. vivax*. In 1928 sixty-seven flies, or 7·4 per cent., were infected with *T. congolense*, and thirty-nine flies, or 4·3 per cent., with *T. vivax*. Over the two years more flies were infected with *congolense* than *vivax*, in the proportion of ten to seven, approximately.

It is difficult to detect any seasonal degree of infection of either group which could be classed as normal for that particular month; for example, in October, 1927, 2·4 per cent. were infected with *T. congolense*, in October, 1928, 11·1 per cent. In the same month, 7·8 per cent. were infected with *T. vivax* in 1927, and 3·5 per cent. in 1928. The dissections made in 1928, however, indicated that there is a definite seasonal rise in the trypanosome infection of both groups: for *congolense*, from 5·8 per cent. in July to 11·1 per cent. in October, and for *vivax* from 2·7 per cent. in June to 7·3 per cent. in November. The rise coincides with the greater visibility of the game in October and November due to the grass fires.

C. *Other Internal Parasites.*—Three flies were found containing filaria and human blood. In 1928, 287 flies, or 32 per cent., harboured intestinal parasites, most probably Leptomonads or *Crithidia*.

## 13. Source of Food of the Flies.

Out of the 905 dissections made in 1928, a hundred were found to contain recognisable mammalian blood and one avian blood. The mammalian bloods were roughly divided into three groups, with the aid of an eye-piece micrometer. The smallest group would include all the big buck; the middle group the small buck, and the largest group, warthog, dog and man. The proportion of each group obtained was fifty-nine large size blood corpuscles, twenty-seven small size blood corpuscles and fourteen medium sized blood corpuscles. It is considered that most of the bloods in the large group are from man, as the native collectors have the habit of allowing the fly to get a partial feed before using the collecting net, and many of the flies dissected were fully engorged.

In 1928, from September onwards, twenty-two flies were found with a slight quantity of red matter in the labrum and gut. It is thought to be of vegetable origin, though no tests were made to prove this.

## 14. Summary.

1. An account is given of two organised grass fires carried out in the Lomagundi fly-belt of Southern Rhodesia in the years 1927 and 1928, as a method of controlling *G. morsitans*.

2. The effect of these fires on the flora and game is described, and details given of the immediate effect of these fires on both the adult fly and the puparia. The effect on the adult fly was to concentrate it along the shady watercourses and other parts of the forest where the fires were less fierce and the requisite shade was to be found.

3. On the puparia, no immediate effect was noticeable. The number of dead puparia collected increased during October and November, and this is considered to be attributable to the lethal effects of the sun, not of the fire.

4. The pupal period of the fly decreases from eighty-two days for puparia collected in June, to twenty-one days for puparia collected in November. The period of greatest activity of the fly, as indicated by emerging flies, density and collected puparia, is in September.

5. A short account is given of the trypansome infection and food of the fly. On the average 11 per cent. of the flies are infected with pathological trypansomes in the proportion of ten *congolense* group to seven *vivax* group. Only one infection of the gland was found out of 1,523 dissections. There is a tendency for the percentage of infected flies to increase during the late dry season. This rise coincides with the increased visibility of the game. Examination of the fat content failed to indicate any degree of starvation amongst the flies.

The food of the fly consists almost entirely of mammalian blood, only one case of avian blood being found.

6. A final decision has not yet been pronounced upon the efficacy of grass fires as a means of controlling *G. morsitans* in Southern Rhodesia.

*References.*

(1) Swynnerton, C. F. M. An Examination of the Tsetse Problem in North Mossurise, Portuguese East Africa. Bull. Ent. Res., xi, 1921, p. 315.

(2) Lloyd, Ll., Johnson, W. B. & Rawson, P. H. Experiments in the Control of Tsetse-fly. Bull. Ent. Res., xvii, 1927, p. 423.

(3) Jack, R. W. Tsetse-fly in the Lomagundi District. Rhodesia Agric. Journal, xxiii, 1926, pp. 134–150, 257–267.

(4) Lloyd, Ll. & Johnson, W. B. The Trypansome Infections of Tsetse-flies in Northern Nigeria and a new Method of Extermination. Bull. Ent. Res., xiv, 1924, p. 265.

TABLE 1.

TABLE SHOWING PERCENTAGE OF PUPARIA THAT FAILED TO EMERGE.

*Weekly Collections.*

| 1927 | Aug. 1-6 | Aug. 7-13 | Aug. 14-20 | Aug. 21-27 | Aug. 25-26* | Aug. 28-Sept. 3 | Sept. 4-10 | Sept. 11-17 | Sept. 18-24 | Sept. 25-27 | | Sept. 30-Oct. 8 | Oct. 9-15 | Oct. 16-22 | Oct. 23-29 | Oct. 30-Nov. 5 | Nov. 6-12 | Nov. 13-19 | Nov. 20-26 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Number bred from ... | 186 | 306 | 209 | 295 | 128 | 521 | 422 | 531 | 353 | 78 | FIRE | 619 | 178 | 261 | 197 | 183 | 165 | 276 | 271 |
| Number emerged or alive on dissection ... | 97 | 159 | 109 | 178 | 50 | 354 | 263 | 375 | 220 | 34 | | 344 | 74 | 166 | 118 | 71 | 33 | 66 | 99 |
| Percent. dead | 48 | 48 | 48 | 40 | 60 | 32 | 38 | 29 | 38 | 64 | | 44 | 58 | 36 | 40 | 61 | 80 | 76 | 64 |

* Early burnt area.
Total collected—5,051.
Total emerged (including parasites)—2,756.
Percentage emerged—54·5 per cent.

| 1928 | June 19-23 | June 24-30 | July 1-7 | July 9-10 | July 11-15* | July 16-21 | July 22-28 | July 29-Aug. 4 | Aug. 5-11 | Aug. 13-19 | Aug. 20-26 | Aug. 27-Sept. 1 | Sept. 2-8 | Sept. 9-15 | Sept. 16-22 | Sept. 23-29 | | Sept. 30-Oct. 6 | Oct. 7-13 | Oct. 14-20 | Oct. 21-27 | Oct. 28-Nov. 3 | Nov. 4-10 | Nov. 11-17 | Nov. 18-24 | Nov. 26-Dec. 1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Number bred from ... | 124 | 332 | 326 | 98 | 193 | 512 | 468 | 465 | 394 | 321 | 369 | 254 | 319 | 292 | 365 | 233 | FIRE | 344 | 161 | 156 | 170 | 117 | 58 | 115 | 101 | 182 |
| Number emerged or alive on dissection | 79 | 179 | 158 | 59 | 100 | 255 | 260 | 225 | 205 | 128 | 222 | 137 | 164 | 169 | 185 | 95 | | 147 | 57 | 27 | 35 | 30 | 9 | 31 | 33 | 51 |
| Percent. dead ... | 36 | 46 | 52 | 40 | 48 | 50 | 44 | 51 | 50 | 60 | 40 | 46 | 49 | 42 | 49 | 59 | | 57 | 65 | 83 | 79 | 73 | 85 | 73 | 67 | 72 |

* Early burnt area.
Total collected—6,469.
**Total emerged (including parasites)—3,040.**
Percentage emerged—47 per cent.
**Over similar period as 1927—44 per cent.**

TABLE 2.
DENSITY COUNTS, FEMALE PERCENTAGE AND ACTIVITY.
*Catch per Net per Hour.*

| | 1927 | | | | | | | | | 1928 | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Winde R.* | Aug. 13 | Aug. 30 | Sept. 13 | Sept. 27 | | Oct. 1 | Oct. 19 | Nov. 4 | Nov. 22 | June 17 | July 5 | July 19 | Aug. 6 | Aug. 22 | Sept. 12 | Sept. 25 | | Oct. 1 | Oct. 15 | Oct. 29 | Nov. 11 | Nov. 27 |
| Density | 42 | 42 | 39 | 13 | FIRE | 31 | 19 | 20 | 9 | 26 | 20 | 39 | 19 | 19 | 19 | 21 | FIRE | 37 | 32 | 16 | 60 | 28 |
| Female per cent. | 19 | 12·5 | 17 | 15 | | 24·4 | 13·6 | 9 | 18 | 23·5 | 31 | 13 | 9·5 | — | 13·6 | 19 | | 23 | 20 | 16 | 17 | 9·6 |
| Activity | 52 | 48 | 47 | 13·3 | FIRE | 41 | 22 | 22 | 11 | 34 | 29 | 45 | 21 | 19 | 22 | 26 | FIRE | 48 | 40 | 19 | 72 | 31 |

1927 Early Burnt Area.

| *Cha-uka* | Aug. 12 | Aug. 29* | Sept. 12 | Sept. 26 | | Sept. 30 | Oct. 17 | Nov. 3 | Nov. 21 | June 19 | July 7 | July 20 | Aug. 7 | Aug. 23 | Sept. 13 | Sept. 26 | | Oct. 2 | Oct. 16 | Oct. 31 | Nov. 14 | Nov. 29 | Aug. 26 | Oct. 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Density | 52 | 26 | 51 | 16 | FIRE | 17 | 11 | 9 | 14 | 22 | 22 | 28 | 35 | 21 | 22 | 8 | FIRE | 33 | 16 | 26 | 8 | 8 | 47 | 20 |
| Female per cent. | 10·4 | 10·4 | 9 | 15·2 | | 5·5 | 21 | — | 6·6 | 8 | 42 | 22 | 24 | 25 | 8·3 | 33 | | 11 | 30 | 21 | 27 | 20 | 11·3 | 13 |
| Activity | 58 | 29 | 56 | 19 | FIRE | 18 | 14 | 9 | 15 | 24 | 38 | 36 | 46 | 28 | 24 | 12 | FIRE | 37 | 23 | 33 | 11 | 10 | 53 | 23 |

| *Motor Rd.* | Aug. 16 | Aug. 30 | Sept. 15 | Sept. 28 | | Oct. 3 | Oct. 28 | Nov. 5 | Nov. 23 | June 22 | July 9 | July 25* | Aug. 8 | Aug. 24 | Sept. 14 | Sept. 27* | | Oct. 3 | Oct. 17 | Nov. 1 | Nov. 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Density | 28 | 53 | 46 | 23 | FIRE | 14 | 12 | 11 | 8 | 39 | 46 | 11 | 48 | 23 | 23 | 9 | FIRE | 20 | 5 | 19 | 15 |
| Female per cent. | 30 | 11·6 | 4·1 | 11·5 | | 33·3 | 20 | — | 11 | 20 | 29 | 15 | 9·4 | 21 | 11·5 | 53 | | 26 | 50 | 21 | 17 |
| Activity | 40 | 60 | 48 | 26 | FIRE | 21 | 15 | 11 | 9 | 49 | 65 | 13 | 53 | 29 | 26 | 19 | FIRE | 27 | 10 | 24 | 18 |

* Cold weather.

TABLE 3.

TABLE SHOWING THE PROPORTION OF FULL AND EMPTY PUPARIA COLLECTED EACH MONTH.

*Not including the Parasitised Empty Cases collected.*

| 1927 | | | | 1928 | | | |
|---|---|---|---|---|---|---|---|
| Month | Full | Empty | Per cent. Full | Month | Full | Empty | Per cent. Full |
| | | | | June* ... | 455 | 5,351 | 8 |
| | | | | July ... | 1,609 | 15,908 | 9 |
| August ... | 1,142 | 12,151 | 8 | August ... | 1,825 | 16,350 | 10 |
| September ... | 2,075 | 20,839 | 9 | September ... | 1,223 | 15,090 | 7·5 |
| October ... | 1,097 | 21,888 | 4 | October ... | 962 | 26,013 | 3·5 |
| November ... | 894 | 19,766 | 4 | November ... | 467 | 14,630 | 4 |
| TOTAL ... | 5,208 | 74,644 | 6 | TOTAL ... | 6,541 | 93,342 | 6 |

* Two weeks only.

TABLE 4.

| *Maximum Pupal Period* 1927 | | | | *Maximum Pupal Period* 1928 | | | |
|---|---|---|---|---|---|---|---|
| Collected | Emerged | Period in Days | Mean Temperature | Collected | Emerged | Period in Days | Mean Temperature |
| | | | | June 19–23 ... | Sept. 7 | 81 | |
| | | | | ,, 26–30 ... | ,, 13 | 82 | 59·7 |
| | | | | July 1– 7 ... | ,, 17 | 79 | |
| | | | | ,, 8–10 ... | ,, 18 | 73 | 56·1 |
| | | | | ,, 16–21 ... | ,, 20 | 68 | |
| | | | | ,, 22–28 ... | ,, 21 | 62 | 56·3 |
| | | | | ,, 29– ... | | | |
| | | | | Aug. 4 ... | ,, 23 | 58 | |
| Aug. 1– 6 ... | Sept. 30 | 61 | | ,, 5–11 ... | ,, 25 | 52 | 59·5 |
| ,, 7–13 ... | Oct. 4 | 59 | 58·7 | ,, 13–19 ... | ,, 29 | 49 | |
| ,, 14–20 ... | ,, 3 | 52 | | ,, 20–26 ... | Oct. 4 | 47 | 63·6 |
| ,, 21–27 ... | ,, 9 | 50 | 63·7 | ,, 27– | | | |
| | | | | Sept. 1 ... | ,, 7 | 43 | |
| ,, 28– | | | | | | | |
| Sept. 3 ... | ,, 13 | 47 | | ,, 2– 8 ... | ,, 13 | 42 | 68·5 |
| ,, 4–10 ... | ,, 17 | 44 | 69·1 | ,, 9–15 ... | ,, 15 | 37 | |
| ,, 11–17 ... | ,, 19 | 39 | | ,, 16–22 ... | ,, 22 | 37 | |
| ,, 18–24 ... | ,, 26 | 39 | 69·3 | ,, 23–29 ... | ,, 26 | 34 | 72·4 |
| ,, 25–27 ... | ,, 30 | 36 | | ,, 30– | | | |
| | | | | Oct. 6 ... | Nov. 2 | 34 | |
| ,, 28– | | | | | | | |
| Oct. 8 ... | Nov. 4 | 38 | | ,, 7–13 ... | ,, 5 | 30 | 75·8 |
| ,, 9–15 ... | ,, 13 | 36 | 77 | ,, 14–20 ... | ,, 15 | 33 | |
| ,, 16–22 ... | ,, 20 | 36 | | ,, 21–27 ... | ,, 19 | 30 | 77·6 |
| ,, 23–29 ... | Dec. 3 | 42 | 74·3 | ,, 28– ... | | | |
| | | | | Nov. 3 ... | ,, 28 | 32 | |
| ,, 30– | | | | | | | |
| Nov. 5 ... | Nov. 30 | 32 | | Nov. 4–10 ... | ,, 24 | 21 | 76·6 |
| ,, 6–12 ... | Dec. 13 | 38 (*a*) | 76·1 | ,, 11–17 ... | Dec. 20 | 40 (1) | |
| ,, 13–19 ... | ,, 21 | 39 (*b*) | | ,, 18–24 ... | ,, 22 | 35 (2) | |
| ,, 20–26 ... | ,, 24 | 35 (*c*) | 73 | ,, 26– | | | |
| | | | | Dec. 1 ... | Jan. 5 | 42 (3) | 78 |

(*a*) 14 days in Salisbury.
(*b*) 22 days in Salisbury.
(*c*) 25 days in Salisbury.

(1) 17 days in Salisbury.
(2) 19 days in Salisbury.
(3) 32 days in Salisbury.

TABLE 5.

TABLE SHOWING INFECTION OF *G. morsitans* WITH TRYPANOSOMES.
*Lomagundi District.* 1927 *and* 1928.

| 1927 | Number dissected | Gut only | Mature *congolense* group | Immature *vivax*. Lab. only | Mature *vivax*. Lab. & Hyp. | Mature gland infection | %immature *congolense* group | %mature *congolense* group | %immature *vivax* group | %mature *vivax* group | %*brucei* | Total % mature infection | %mature and immature |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| August ... | 57 | — | 4 | — | 2 | — | — | 7 | — | 3·5 | — | 10·5 | — |
| September ... | 134 | — | 9 | — | 3 | — | — | 6·7 | — | 2·2 | — | 9 | — |
| October ... | 167 | — | 4 | — | 13 | — | — | 2·4 | — | 7·8 | — | 10·1 | — |
| November ... | 260 | — | 13 | — | 15 | — | — | 5 | — | 5·8 | — | 10·8 | — |
| 1928. June ... ... | 36 | 2 | 3 | — | 1 | — | 5·5 | 8·3 | — | 2·7 | — | 11 | 16·6 |
| July ... ... | 137 | 6 | 8 | 2 | 4 | — | 4·3 | 5·8 | 1·4 | 2·9 | — | 8·7 | 14·6 |
| August ... | 163 | 5 | 11 | — | 4 | — | 3·0 | 6·7 | — | 2·4 | — | 9·1 | 12·3 |
| September ... | 183 | 3 | 12 | 3 | 8 | — | 1·6 | 6·6 | 1·6 | 4·3 | — | 10·9 | 14·2 |
| October ... | 170 | 1 | 19 | 1 | 6 | *brucei* 1 | 0·5 | 11·1 | 0·5 | 3·5 | 0·5 | 15·1 | 16·4 |
| November ... | 216 | 2 | 14 | 2 | 16 | — | 0·9 | 6·5 | 0·9 | 7·3 | — | 13·8 | 15·7 |

NOTE.—It is reasonable to assume that all immature infection of the " gut only " represent infection with trypanosomes of the *congolense* group as the total infection by the trypanosomes of the *brucei* group was only 0·1 per cent.

TABLE 6.

TEMPERATURE RECORDS.
*Fortnightly Means.*

| 1927 | | | | | | | 1928 | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Month | Abs. Max. | Abs. Min. | Mean Max. | Mean Min. | Mean $\frac{M+m}{2}$ | Rel. Hum. | Month | Abs. Max. | Abs. Min. | Mean Max. | Mean Min. | Mean $\frac{M+m}{2}$ | Rel. Hum. |
| | | | | | | | June | 79 | 38 | 73 | 45·6 | 59·7 | 60·4 |
| | | | | | | | July | 74<br>74 | 37<br>38 | 70<br>71 | 42<br>41·5 | 56·1<br>56·3 | 78·6<br>58·6 |
| Aug. | 77<br>85 | 41·5<br>43 | 71<br>77·5 | 46·1<br>49·6 | 58·7<br>63·7 | 70<br>62 | Aug. | 81·5<br>83 | 38<br>43 | 73·1<br>78 | 45·8<br>49 | 59·5<br>63·6 | 66<br>52 |
| Sept. | 89<br>91 | 52<br>50 | 82<br>82·5 | 56·4<br>56·8 | 69·1<br>69·3 | 58<br>52 | Sept. | 90<br>94·5 | 52<br>52 | 81·4<br>85·4 | 55·4<br>58·8 | 68·5<br>72·4 | 52<br>57 |
| Oct. | 91<br>89 | 58<br>60 | 88·8<br>84 | 65<br>64·6 | 77<br>74·3 | 42<br>62 | Oct. | 93<br>95 | 53<br>59 | 90<br>90·5 | 61·8<br>65 | 75·8<br>77·6 | 54<br>54 |
| Nov. | 93·5<br>90 | 57<br>61 | 87·6<br>82·8 | 65·2<br>64 | 76·1<br>73 | 55<br>66 | Nov. | 94<br>93 | 56<br>62 | 90<br>88 | 63·7<br>67·6 | 76·6<br>78 | 55<br>65 |

# NEW TRYPETIDAE FROM SOUTH AFRICA (DIPT.).

By H. K. Munro, B.Sc., F.E.S.

(Plate XV.)

In discussing the African Trypetidae some mention should be made of the work of the late Dr. Mario Bezzi, who has perhaps done most work on the higher Diptera of Africa and on the Trypetidae in particular. In 1924 in his papers in Vol. xv of the "Bulletin of Entomological Research" and in Vol. xix of the "Annals of the South African Museum," Bezzi left the classification of the African Trypetidae in as satisfactory a condition as any systematic group could be expected to be at any given time. Some discrepancy was apparent, however, between the classification of the African and of the European Trypetidae, the general classification of the latter apparently not having been touched since Loew's early work. The appearance, therefore, of Dr. F. Hendel's monograph on the Palaearctic Trypetidae in Lindner's "Die Fliegen der Palaearktischen Region" was greatly to be welcomed. At the same time, his classification does not agree with that of Bezzi; Hendel has made numerous nomenclatorial and systematic changes, and the correlation of the two systems will not always be easy.

In the general consideration of systematic work there is one point that is of some importance, and that is the condition of reared specimens, which are more often than not very unsatisfactory. I would, therefore, urgently appeal to all workers, especially those engaged on economic problems, to obtain better bred specimens. After several years' experience in rearing and in examining reared specimens of various orders, and especially of Diptera, I have come to the conclusion that the greatest fault to which most workers are subject is to kill specimens almost immediately after emergence from the pupal stage—I have even seen flies pinned before the wings had expanded. It should, therefore, be borne in mind that not only must the chitin be given time to harden, but that the coloration must also be allowed to develop. The result of killing specimens (particularly Diptera) too soon is that the coloration is imperfect, usually very pale and diffuse, and (more serious still) the body walls collapse on drying, the shape of the body and of various parts being often much distorted. Thus the identification of specimens—perhaps of great economic importance—is rendered very difficult, if not impossible, or they may even be described as new species.

So far as the Trypetidae are concerned, I have found that in order to get fully hardened and coloured specimens, it is necessary to keep them alive for nearly a week, feeding them on small amounts of honey and water. In practice, however, it may not be convenient to keep specimens alive for this length of time, but they should be allowed to live at least till the day following emergence, or even for two days after, supplying them with a little water on the first day or two.

**Dacus (Dacus) stentor,** sp. n. (Pl. xv, fig. 1).

A large species that belongs to the same group as those placed by Bezzi in *Tridacus*; following Hendel, however, *Tridacus*, Bez., must be considered a synonym of *Dacus*, Fabr., s. str. In general appearance the species much resembles *D. lounsburyi*, Coq., and *D. sphaeristicus*, Speis., especially in the wing pattern, but differs in having the supra-alar bristle. It differs from other species, such as *D. chrysomphalus*, Bez., and *D. pectoralis*, Walk., in the wing pattern.

♂. Length of body 10·5 mm., of wing 8 mm. Of the usual reddish colour common to the Dacinae. Head: occiput reddish with a narrow ill-defined yellowish

margin along the top and sides ; face with two large comma-shaped spots ; frons with parallel sides, length to width 4 : 3, a wide rounded tubercle anteriorly which is slightly prominent in profile, plain brownish in type, but with blackish spots on sites of bristles and in centre in paratype, ocellar dot blackened in paratype only ; lunule reddish ; two inferior orbital bristles ; antennae long, first joints porrect and closely apposed, first and second of equal length, third nearly three times as long as either, blackish, more so towards the tip ; arista slender, only slightly longer than third joint ; palpi flattened, reddish ; proboscis short. Thorax reddish, finely punctulate, with golden pubescence on dorsum and very fine pubescence on sides; humeri with yellowish tinge, almost entirely yellow in front ; mesopleural stripe narrow ; hypopleural spots mottled yellow ; three narrow reddish dorsal longitudinal stripes, the median one yellow behind suture ; anterior supra-alar bristles present ; scutellum yellow except narrow reddish base above, with two bristles ; halteres whitish. Wings with normal venation ; a strong anal stripe is present and the outer half of the wing broadly infuscated to a line running through the upper and lower cross-veins, and a narrow infuscation along the base of the costa ; thus, the costal cells, the stigma (which is not darker), the marginal, submarginal and first posterior cells (except a very narrow margin at the apex of the wing in the latter), are completely infuscated ; the first basal cell is infuscated towards its base above the second basal cell and slightly at its outer end along the upper cross-vein, the discal cell in its upper outer corner and the second posterior cell, except a paler border along the margin of the wing ; the infuscation is darker in the first posterior cell and in the contiguous portions of the surrounding cells. Legs with coxae, femora and tibiae concolorous with darker portions of the body, except rather more than half of the proximal end of hind femora, which is yellow ; first tarsal joint and pulvilli yellowish, others not quite so dark as the femora. Abdomen concolorous with thorax and with similar golden pubescence ; third segment ciliated ; genitalia reddish.

Two male specimens, type and paratype, taken on the farm Stentor, Barberton district, Transvaal, iii.1927 (*L. S. Hulley*).

**Dacus (Leptoxyda) brevistriga,** Walk. 1861.

*Dacus asclepiadens*, Bez., Ann. S. A. Mus., xix, 1924, p. 469.

The species *asclepiadens*, Bez., was founded on two teneral female specimens and must be regarded as a synonym of *Dacus brevistriga*, Walk., for the following reasons, based on a study of the type returned by Bezzi and on two other female specimens belonging to the same lot of material.

The specimens are generally paler than is normal in *brevistriga* as the coloration is undeveloped, the specimens apparently having been killed soon after emergence from the puparium. This lack of intensity of colour applies particularly to the legs and wings, and it is also responsible for the conspicuousness of the dorsal stripe on the thorax. The bodies of the specimens are much collapsed, especially the head, and the abdomen is so contracted laterally that it is conspicuously elongated. By treating the abdomen of one specimen in potash and hardening in alcohol, it was possible to restore it almost to its original shape ; it is rather more elongated than is normal in *brevistriga*, but this may be due to the original distortion. The sutures of the abdominal segments are firmly fused, in which the specimen agrees with *D. brevistriga* and differs particularly from *D. fuscatus*, Wd. Bezzi states that the ovipositor is " greatly swollen at base," but this is only due to extreme flattening owing to the collapse of the soft walls on drying ; the restored ovipositor agrees with that of normal specimens of *brevistriga*.

**Nippia,** gen. n.

Head short and broad, bristles moderately long, two inferior orbitals, lower occipital swellings not prominent ; frons flat ; antennae rather long, second joint

prominent and bristly, third joint rather narrow and rounded at end ; arista shortly plumose. Thorax with complete chaetotaxy, dorso-centrals just behind the line of the anterior supra-alars ; two mesopleurals. Legs short. Wings with a broadly banded-reticulate pattern in genotype ; third vein sparsely bristly on basal half ; first vein ending beyond anterior cross-vein, which is before the middle of discal cell, anal cross-vein deeply bent in middle. Scutellum with four bristles. Abdomen short. Basal joint of ovipositor massive, broadly tubular, somewhat narrowed at extreme base and flattened at apex.

The genus belongs to the small group of Ceratitine genera that includes *Carpophthoromyia*, Bez., *Leucotaeniella*, Bez., *Chelyophora*, Rond., *Bistrispinaria*, Speis., and *Clinotaenia*, Bez., as well as probably *Perilampsis*, Bez. It differs from all described species of these genera in the peculiar wing-pattern (of the genotype at least). In one important character, the shape of the basal joint of the ovipositor (generally referred to as " the ovipositor ") it is very similar to species of *Carpophthoromyia*, the shape being very similar to that of *C. dimidiata*, Bez., as well as to species of *Perilampsis*. (The shape of this joint in *Carpophthoromyia superba*, Bez., does not seem to be typical.) In the species of the other genera mentioned above, the basal joint of the ovipositor, so far as is recorded, is flattened at the base and is more or less triangular.

*Nippia* agrees with *Chelyophora*, *Bistrispinaria* and *Clinotaenia* in having the second antennal joint prominent and spinulose above, and with the last-named in having only two inferior orbital bristles. From all the genera previously mentioned it differs in its more thick-set appearance, the much shortened head, the wing-pattern and the position of the anterior cross-vein.

Genotype : the following new species.

**Nippia alboscutellata,** sp. n. (Pl. xv, fig. 2).

A thick-set, blackish species, with a broadly banded-reticulate wing-pattern and a white scutellum.

♀. Length of body and of wing 5 mm. Head short and broad, height to length to width, 5 : 3 : 7 ; frons width at vertex less than length (2 : 2·5), slightly narrowed at antennae, rather narrower than one eye, smooth, flat, blackish-yellow on front two-thirds, whitish on hind third, with a dark brown vertical spot, angle with face not prominent in profile ; two inferior and two superior orbitals (all missing in specimen), ocellars medium ; face convex, dull blackish-yellow, parafacials as wide as, and genae twice as wide as third antennal joint ; mouth short and wide, not very large, epistome not at all prominent ; proboscis short, brownish ; palpi short, flattened, brownish ; genal bristle medium ; occiput flat, black and narrowly yellow along top, lower swellings not prominent ; antennae short, not reaching much below middle of face, second joint prominent, with black bristles above, third joint yellow, rounded at end ; arista black, thickened at base, shortly plumose, nearly three times as long as third antennal joint. Thorax with dorso-centrals a little behind line of anterior supra-alars and half way between suture and scutellum. Thorax dark blackish-brown, lighter on dorsum and humeri and with a whitish, rather broad bar from humeri to near base of wings. Legs with coxae yellowish, femora dark brownish-black, tibiae and tarsi straw-coloured, bristles and pubescence black, front femora with a row of strong antero-lateral bristles, middle tibiae with a row of short antero-ventral spines and one strong and two shorter apical bristles. Wings twice as long as wide ; pattern formed of three irregular, more or less confluent, transverse bands forming a broadly reticulate pattern ; costal bristle short ; stigma black, about twice as long as width at base ; costa slightly curved forwards ; second vein almost straight, but irregular ; third vein bent downwards towards end, sparsely bristly on basal half above ;

anterior cross-vein before middle of discal cell and slightly inclined inwards (towards head), posterior cross-vein slightly curved and inclined outwards, anal cross-vein deeply bent in middle and anal cell with a fairly long point. Scutellum nearly twice as wide as long, ivory white, quite bare, with four bristles, the apicals the shorter. Halteres whitish. Thoracic squamae elongate, yellowish. Abdomen short, dark brownish, and with last three segments yellowish on hind margins; sixth segment in female shorter than fifth, each with strong black bristles laterally, and shorter bristles on hind margins; ovipositor much like that of *Carpophthoromyia dimidiata*, Bez., massive, broadly tubular, slightly constricted at base and flattened apically, shiny blackish-brown with black pubescence, as long as the abdomen.

Type, a single female specimen collected on the farm Stentor, Barberton district, Transvaal, 19.x.1926 (*L. S. Hulley*).

**Perilampsis diademata,** Bez. 1924.

A male and a female specimen of this species from Bulawayo, Southern Rhodesia (19.i.1927 and 27.iv.1927, *R. H. R. Stevenson*) agree with the type, but are more blackish in general body colour. (The type, although collected, may be a slightly teneral specimen.) The ovipositor is of the same type as that of *Carpophthoromyia* and *Nippia* and unlike that of *Ceratitis* s. l. The basal joint of the ovipositor is long and tubular-conical, flattened dorso-ventrally, slightly arched upwards and nearly twice as long as the abdomen; at the base the width is rather less than half the length, tapering to half this width at the apical third, the following sixth tapers rather more sharply, and the apical sixth is cylindrical.

**Perilampsis amazuluana,** sp. n. (Pl. xv, fig. 3).

Allied to *P. pulchella* (Aust.) and *P. diademata*, Bez., but generally paler and less shining black, with yellow legs and no dark bar across the top of face and base of antennae; the middle band in the wing pattern is more or less fused with the marginal.

♂. Length of body 4·5 mm., of wing 4 mm. Head pale, occiput light brown above with darker brownish spot on either side, yellowish below shading to pale yellow on genae; face white, hollowed; mouth-opening wide, epistome straight; proboscis short, yellowish; palpi whitish; antennae (third joint missing) dark yellow; frons twice as long as wide, posterior two-thirds deep velvety brown, anterior third brownish-yellow; ocellar dot greyish; the two superior orbital bristles on greyish elongated plates; two inferior orbitals; ocellars long; all bristles black. Dorsum of thorax rather dull black, with a large central area covered with thick grey dust and white pubescence; humeri and a very broad stripe across pleura ivory-white, as also are hypopleura; rest of pleura brown shading to the yellowish sterna. Legs straw-colour, front femora with row of strong black bristles. Scutellum ivory-white with four black bristles, the apicals the shorter. Wings normal; anterior cross-vein at middle of discal cell, which has the lower angle acute; base of wing infuscated, basal band much attenuated towards hind margin of wing, marginal band united to basal; middle band wide and closely approximated to marginal, or even fused towards margin of wing and then separated by a short hyaline streak; cubital band separated from marginal. Abdomen brownish black, with posterior third of second and fourth segments paler brownish with grey dust; pubescence fine and yellowish; genitalia blackish.

Type, male, Zululand (no precise locality) 2.i.1922 (*R. H. Harris*); paratype male (without head), Empangeni, Zululand, i.1928 (*M. C. Mossop*).

**Pardalaspis scaevolae,** sp. n. (Pl. xv, fig. 4).

This species appears to come between Bezzi's two main groups of the species of *Pardalaspis*, and to be more nearly related to *P. stictica*, Bez. The middle band across

the last portion of the fourth vein is absent, but the cubital, across the lower cross-vein, is united to the basal; the marginal is also united to the basal, as in *P. stictica*, and the black spots on the scutellum are not separated.

♂♀. Length of body 4 mm. to 4·9 mm., of wing 4 mm. to 4·7 mm. Head normal, yellow; occiput paler yellow, with slight brown central marks; antennae yellow, arista bare, brown on apical three-fourths; bristles black, two inferior orbitals. Dorsum of thorax light brown with short yellow pubescence; humeri yellowish white, unspotted; there are the following marks on the dorsum—two elongate spots above neck, two large spots on each side, one behind and one on the inner side of each humerus, two submedian spots just below suture and a small spot centrally between them, two larger spots before scutellum and a large elongate spot on each side above the base of wing between suture and scutellum; pleura whitish to yellowish, with yellow hairs; a single mesopleural bristle; sterna yellow. Legs yellow, femora rather swollen, a row of strong black bristles on front pair. Halteres yellow. Scutellum black, with a broad white base, the black being separated into three lobes by indentations of the white, the lateral lobes smaller and rounded, the median broad and subrectangular. Mesophragma black, its lower half thickly grey-dusted, the upper shining black with a narrow grey-dusted line between it and the scutellum. Wing normal; in addition to a few isolated spots at base, there is a complete basal band, a broad costal united to the basal, and a complete cubital also united to the basal; there is no band across the last portion of the fourth vein. Abdomen rather dark yellow, with posterior halves of second and fourth segments broadly dusted with thick grey dust; clothed with short hairs, with definite rows of bristles on the hind margins of the segments, being longest on the last segment; hairs and bristles black, except hairs on last segment which are yellow. Male genitalia black; ovipositor brown, short, only as long as last segment.

Type, male and female, three good male paratypes and three damaged male paratypes.

The larvae were found infesting the fruits of *Scaevola lobelia* in Durban during April and May, 1925 (*C. C. Kent*).

### **Afreutreta,** Bez. 1924.

The species of *Afreutreta* and of certain other genera to be considered seem to form a natural group that includes species, all of which, so far as is known, are gall-forming in the larval stage. Systematically they are related to Hendel's DITRICHINI, and apparently to other African genera such as *Eutretosoma* and *Rhochmopterum*. They differ, however, from the latter two genera in the absence of pre-ocellar bristles. From the DITRICHINI, as delimited by Hendel, there are the following differences: in co-relation with the narrower head, the antennae are closer together, being not more than the width of the first joint apart, and the frons is not more than twice the width of an eye; the third antennal joint is broad and rounded at the apex; as in the DITRICHINI the occipital bristles are thickened and yellowish, and the third vein is more or less bristly above; there may or may not be a spot between the root of the antennae and the eye on either side.

In one character the group seems anomalous, so far as Hendel's definition of his subfamily TEPHRITINAE is concerned, namely in the relative lengths of the fifth and sixth abdominal segments in the female; in the present forms the sixth segment is barely as long as the fifth or shorter. However, in view of other characters, *e.g.*, the occipital bristles, etc., it seems advisable to retain the group with the others placed by Hendel in the TEPHRITINAE, at least until it is possible for a revision of the family, based not merely on Palaearctic or Ethiopian forms, but on the TRYPETIDAE of the world, to be made.

Bezzi includes the following species in *Afreutreta*:—*frauenfeldi* (Schin.), *millepunctata*, Bez. (and its variety *limbatella*, Bez.), *discoidalis*, Bez., *bipunctata* (Lw.) and *biseriata*, Bez. As shown in Bezzi's table of the species (Bull. Ent. Res., xv, p. 128), they fall into two groups, those with broadened and those with normally shaped wings. There is, however, another character, not noted by Bezzi, which follows the same division, namely the presence of bristles on the upper side of the third vein. In his descriptions and notes Bezzi either does not mention this character, or states that the vein is bare.

As regards *bipunctata*, careful examination shows that there are normally six bristles at the base of the third vein—two on the swelling at the junction of the second and third veins, three just beyond it, and one a little farther out. Of *biseriata* I have not seen specimens, but in spite of the fact that Bezzi states that the third vein is bare, it will with little doubt be found to have a few as in *bipunctata*.

All the other species mentioned above, that is, those with broadened wings, have a more or less complete row of bristles along the third vein. In *frauenfeldi* and *discoidalis* there is a row of bristles somewhat sparsely spaced from the swelling to near the end of the vein. In *limbatella* there are three or four bristles just beyond the swelling and a further four or five on the third quarter of the vein from the base; *millepunctata*, of which I have not seen specimens, is probably the same.

Other characters in which the species agree are: three inferior orbital bristles, two superior orbitals, four scutellars, and the rounded end of the third antennal joint (not mentioned in the description of *biseriata*), and the spot at the root of the antennae (absent in *biseriata*). Another interesting character common to all, except perhaps *biseriata*, is that the small white spots on the wings are not due to lighter spots in the wing membrane, but to small groups of white microtrichiae.

Of other species that form the gall-making complex and that seem to be related to the above-mentioned species of *Afreutreta*, there are *Acanthiophilus muiri*, Bez., and *A. hemimelas*, Bez. They agree with the species of *Afreutreta* in having three inferior orbitals, two superior orbitals and four scutellars; as in *biseriata*, however, there is no spot at the root of the antennae. As regards the bristles on the upper side of the third vein, *muiri* has a few at the base, but *hemimelas* has only a single bristle near the base. On the whole, however, *muiri* and *hemimelas* seem to show a closer relationship to *biseriata*, and it may be suggested that the latter species does not belong to *Afreutreta*, but rather that it is congeneric with the other two species. The inclusion of the three in *Acanthiophilus* seems questionable; the presence of bristles on the upper side of the third vein at the base (not recorded for *biseriata*), the general conformation of the head and other characters appear to exclude them, but a careful comparison with the genotype, *Acanthiophilus walkeri* (Wollast.) and other European species placed in the genus is necessary before a decision can be made.

**Parafreutreta,** gen. n.

Related to *Afreutreta*, more particularly to *A. discoidalis*, Bez., but differing mainly in having only two inferior orbital bristles, and in the absence of a spot at the root of the antennae (the species *biseriata*, Bez., is provisionally excluded from *Afreutreta*).

Head short, height nearly twice length; occiput concave above, convex below; occipital bristles whitish and thickened; frons flat, sloping, hardly prominent in front, about as long as wide, but narrowed in front, wider than an eye, but not more than twice as wide; two inferior and two superior orbital bristles, the latter directed backwards; face somewhat concave, with a flattened median ridge, epistome somewhat prominent; mouth-opening rounded or widened; third antennal joint short and broad, rounded at end; dorso-central bristles just before line of anterior supra-alars; four scutellars; wing venation normal; third vein bristly to near end on upper side; apex

of anal cell acutely pointed; legs normal; sixth segment of abdomen in female one-third shorter than fifth in genotype; ovipositor short, broadly flattened conical.

Genotype: *Camaromyia conferta*, Bez.

**Parafreutreta conferta** (Bez. 1926).

*Camaromyia conferta*, Bezzi, Boll. Lab. Zool. Portici, xviii, p. 293, fig. II, C (1926); Munro, Union of S. Afr., Dept. Agric., Ent. Memoir v, p. 30 (1926).

Bezzi placed this species in *Camaromyia*, but stated that it might belong to *Afreutreta*. That it does not belong to *Camaromyia* is apparent from the shape of the head (the occiput being concave above), the absence of sexual dimorphism, and the presence of a row of bristles along the upper side of the third vein, this last fact having been noted by Bezzi. So far as the species of *Afreutreta* are concerned, *conferta* seems to be more closely related to *A. discoidalis*, Bez., and to the other species with widened wings, rather than to *A. bipunctata* (Lw.), especially on account of the bristles along the third vein—in *A. bipunctata* there are only a few at the base of the third vein. It may also be noted that there are two inferior and two superior orbital bristles; Bezzi states there are "1–2 orbitals." The frons is not produced to any extent anteriorly, so that the antennae do not project greatly beyond the contour of the head in profile; the parafacials are narrow, being half the width of the third antennal joint; the eyes are relatively large and more regularly oval, and the lower portion of the occiput is not greatly swollen. Further, as the sixth segment of the abdomen in the female is about one-third shorter than the fifth, the species cannot strictly be included in Hendel's TEPHRITINAE, in which, however, it would seem to belong.

Specimens of the species reared from puparia in galls on stems of *Senecio angulatus* at Durban by E. W. Rust, are of a much larger average size than are those from East London, the type locality; also the size is more constant, the wing length, for instance, varying little between 4·5 mm. and 4·8 mm., while in the East London specimens the wing-length varies from 2·5 mm. to 4 mm. The wing-pattern in the Durban specimens is rather more diffuse, the spots are yellowish sub-hyaline, and the light band across the wing is not composed of a continuous row of rather large whitish-hyaline spots, but by a greater or less confluence of a band of spots across the wing, all having a yellowish tinge. In the general appearance of the wing, however, there is a fairly distinct middle band and an apical band separated by the lighter band described.

The galls and the larvae are of a correspondingly larger average size.

**Parafreutreta pretoriae,** sp. n. (Pl. xv, fig. 5).

Very like *Parafreutreta conferta* (Bez.) in appearance, more so to the larger specimens from Durban. It differs from *P. conferta* in the proportions of the head and in wing-pattern. The frons is longer in profile and more prominent in front; the parafacials are wider; the eye relatively smaller, and the occiput more swollen below.

♂. Length of body 5·5 mm., of wing 5·4 mm. An entirely brownish species. Head yellowish; face wide, concave, with a flat median ridge which is wider on epistome and narrowed below antennae; epistome hardly prominent; parafacials as wide as third antennal joint; frons yellow, with some yellow and some black pubescence, rather wider than long, with parallel sides, flat, but rather swollen in front and somewhat prominent anteriorly in profile; two inferior and two superior orbital bristles, the latter directed backwards and the upper one pale brown; vertical plates narrow, whitish; post-vertical bristles whitish, occipitals pale brown, ocellars long; all bristles black except as noted otherwise. Lunule large and prominent, whitish; antennae inserted opposite middle of eye, more prominent in profile than

in *P. conferta*, half the length of the face, third joint short and broad, straight on upper side, rounded at end; arista bare, brown. Occiput brownish, rather concave above, with a pair of black spots above neck, each spot covered with thick grey dust except on its margins; lower portion of occiput swollen, clothed with rather long pale brownish hairs. Mouth-opening rounded, not very large; proboscis short, yellow; palpi flat, yellow. Thorax brown, dorsum with short yellow pubescence and with three darker brown lines on front two-thirds; bristles dark brown, dorso-centrals slightly before line of anterior supra-alars; prescutellars closer together than dorso-centrals; pleura with all bristles pale brown, except upper of two mesopleurals which is brown. Scutellum flat, brown like thorax and with yellow pubescence; four dark brown bristles of equal length. Wings rather long and narrow; brown with yellowish and whitish sub-hyaline spots; markings darker along fore half to and including apex of wing and down to hind margin across hind cross-vein, leaving hind portion of wing and outer portion of second posterior cell paler and more reticulate; stigma elongate, with a very slight paler spot at outer third; discal cell elongate, anterior cross-vein towards its outer end, the latter about its own length from lower cross-vein; third vein sparsely bristly to near end; point of anal cell acute. Abdomen brown with yellow pubescence, and a fringe of brownish bristles on hind margin of last segment; genitalia brown.

Type, male, a single specimen taken in the Fountains Valley, Pretoria, 19.xi.1926 (*H. K. Munro*).

**Parafreutreta bryanti,** sp. n. (Pl. xv, fig. 6).

A remarkable gall-forming species which belongs to the same biological group as the species of *Afreutreta, Parafreutreta* and *Acanthiophilus* already discussed. Its nearest ally is *Parafreutreta conferta* (Bez.); its biology is practically identical, and systematically it shows close relationship. It differs from *P. conferta* in having the wings practically hyaline and only two inferior orbital bristles. On account of the latter character, the species should strictly not be included in *Parafreutreta*, as the genus has been defined. It is, however, placed there, at least provisionally, on account of its undoubted relationship to *P. conferta*, more particularly in the form of the ovipositor and in the relative lengths of the fifth and sixth abdominal segments in the female. In regard to the latter point, as the sixth segment is the shorter, neither this species nor *P. conferta* should be included in Hendel's TEPHRITINAE; on the other hand they do not seem to fall naturally in his TRYPETINAE.

♀. A slate-grey species with yellow head and legs and faintly infuscated, almost hyaline, wings. Length of body 4·4 mm., of wing 3·7 mm. Head yellow, short, length to width to height 3 : 5·5 : 5; occiput flattened, slightly concave above, blackish centrally above neck, otherwise yellowish, lower swelling not prominent, with long yellow and some black hairs; occipital bristles white, slightly thickened; frons broad, with slight pubescence centrally and on eye margins, blackish yellow, as long as wide, twice as wide as one eye, lateral margins slightly curved outwards, strongly sloping; two inferior orbital and one superior, the latter and the inner verticals strongly directed backwards over thorax; ocellars rather short; all bristles brownish except whitish post-verticals; lunule yellow, inconspicuous; antennae yellow, short, reaching a little below middle of face; second joint rather large, bristly; third joint rounded at end but with a peculiar darkened point appearing as if it were adventitiously attached to the apex. Face whitish yellow, flattened; parafacials narrow, genae as wide as third antennal joint; mouth-opening relatively small, epistome not prominent; proboscis short, labellae almost as long as haustellum and directed backwards; palpi flat, yellow at apex, paler at base. Thorax black with thick blue-grey dust and white pubescence; bristles black, normal, dorso-centrals on line of anterior supra-alars; humeri and an indistinct stripe to base of wings blackish yellow; pubescence scant on pleura, longer and thicker on

sterna. Scutellum flat, blackish yellow, scant pubescence on margins and four bristles of equal length. Legs straw-yellow, with brown patch on underside of hind femora; halteres yellow. Wings yellowish sub-hyaline, without definite pattern; venation normal, upper cross-vein beyond middle of discal cell, short and twice its length from lower; stigma yellow; cells at base of wing with slight blackish infuscation extending very faintly on either side of veins, along second and third veins nearly to ends, along fourth vein to lower cross-vein, thence almost imperceptibly nearly to end and similarly along fifth vein and lower cross-vein. (The infuscation appears rather accentuated in the figure.) Abdomen dull black, without grey dust, but with white pubescence which is longer posteriorly and a few black bristles on hind margin of last segment; sixth segment shorter than the fifth (2 : 2·5); ovipositor wedge-shaped, convexly rounded above and below, with parallel sides and flattened apex, total length about equal to last two segments together, but only half the length visible from above, blackish on basal half, reddish apically except extreme apex black, white pubescence below and near base above.

Type and paratype, two female specimens reared from puparia found in stem-galls on *Senecio* (*Kleinia*) *longiflora* at Prieska, Cape Province, vii.1928 (*E. G. Bryant*).

**Trypanea lignoptera,** sp. n. (Pl. xv, fig. 7).

A large species that may be readily traced to *Trypanea* in Hendel's tables (Lindner's Fliegen Pal. Reg., xlix, Tryp., p. 23), and there seems to be no reason for not including it in this genus. It differs from other species of *Trypanea* with two scutellar bristles in the peculiarly infuscated wings. It may be noted that those species with four scutellar bristles which Bezzi places in *Trypanea* in his tables (Bull. Ent. Res., xv, pp. 141–142) would appear to be located in *Acanthiophilus* according to Hendel.

♂♀. Length of body 3·5 mm. to 6·2 mm., of wing 3·6 mm. to 5 mm. Head yellow, normal, three inferior and two superior orbital bristles, occipitals whitish and thickened, upper of the two superior orbitals white, other bristles black; proboscis short, not geniculate. Thorax normal, thickly grey-dusted and with white pubescence; humeri, base of wings and a narrow line between yellowish; legs yellow with black pubescence and bristles; halteres yellow. Wings of normal shape and venation; veins straw-yellow at base, dark brown outwardly; no definite wing-pattern, but upper half of wing more or less infuscated from humeral cross-vein to near tip; the infuscation varies in intensity, forming darker or blacker spots and lines; outer costal cell slightly infuscated, stigma almost black, marginal cell slightly infuscated with a large blackened spot below stigma and one at and filling its apex, with a smaller spot nearer the apex between; submarginal cell similarly marked and with a blackened line above third vein beyond upper cross-vein, the apex hyaline; first basal cell slightly infuscated, with a blackened line below third vein and a spot before upper cross-vein; first posterior cell with lines below third and above fourth veins on its proximal three-fourths, apex hyaline; discal cell with slight blackening in upper outer corner and a spot on fifth vein extending into third posterior cell; second posterior cell with slight darkening in upper portion and on end of fifth vein, hyaline outwardly; third posterior cell hyaline except spot on fifth vein already mentioned; in some specimens the blackening is more extended, the spots being larger and coalescing with the lines, thus the middle portions of the submarginal and first posterior cells may be almost quite blackened. Abdomen normal, rather dull black, with slight grey dust and white pubescence; bristles present on sides of segments and on posterior margin of last segment; male genitalia black; ovipositor with basal joint shining black, flattened in dry specimens, triangular, but truncate at apex, as long as last two segments together.

Type, male and female, and some other specimens reared from puparia found in terminal twig galls on *Berkheya magaliesmontana*, Pretoria, viii.1928 (*H. K. Munro*).

For lack of opportunity it has not been possible to make extended observations on the biology and habits of this Trypetid. Puparia were found in August 1928, and adults emerged almost at once. The larva appears to live in the soft tissue of a growing tip ; this results in a certain amount of swelling at the end of the stem, which becomes stunted ; the leaves develop to some extent, forming a rosette, but the end of the stem is eventually killed. The gall itself is quite inconspicuous. When the larva pupates, the walls of the gall become very firmly glued round the puparium.

**Insizwa,** gen. n.

Allied to *Euaresta,* Lw., and *Euarestella,* Hend., and has a similar wing-pattern, but differs in having three inferior orbital bristles and the labellae longer than broad. The upper side of the third vein is bare. It may be characterised as follows: Three inferior and two upper orbital bristles, the hinder of the latter directed backwards ; occipitals yellowish and thickened ; frons bare and flat ; apex of third antennal joint pointed above ; labellae broad, but longer than broad and directed backwards ; dorso-central bristles on suture and well before line of anterior supra-alars ; four scutellar bristles ; wing-pattern *Euaresta*-like, third vein bare above ; sixth abdominal segment of female longer than fifth.

Genotype : the following new species.

**Insizwa striatifrons,** sp. n. (Pl. xv, fig. 8).

A fine large species with *Euaresta*-like wing-pattern, dark olive-buff to buff-brown in colour, and with well-defined broad stripes on frons and on dorsum of thorax.

♂♀. Length of body and of wing 4 mm. to 5 mm., body of female relatively longer than that of male. Head more or less spherical, dark olive-buff, except frons ; face slightly concave, with brownish lateral ridges ; parafacials about one-third width of third antennal joint ; genal bristle dark brown ; mouth-opening large, broadly oval, epistome prominent ; proboscis yellow, labellae laterally flattened in dry specimens, leaf-like, longer than broad, directed backwards and darker in colour ; haustellum nearly as long as mouth. Eyes large, broadly oval. Antennae nearly as long as face, third joint darker, one and one-half times as long as wide, upper end of apex a rounded point ; arista brown, microscopically pubescent. Frons flat, bare, prominent anteriorly in profile, its plane at right angles to the plane of the face ; three inferior orbitals, the lowest shorter and yellowish, on a line with the base of the antennae, the upper two longer and blackish ; two superior orbitals, the lower blackish, the upper directed backwards, yellowish ; the ocellars and outer verticals blackish ; occipitals yellowish and thickened ; on either side of the frons is a broad slate-blue stripe, and a median stripe of the same colour, the latter narrow in front widening to vertex which it includes, but the ocellar dot itself is blackish ; the slate-blue stripes are separated by broad chestnut-brown to dark olive-buff stripes ; lunule bluish to brownish, flat ; occiput dark olive-buff but blackish above neck, somewhat swollen below. Thorax dark olive-buff on sides, shading to slate-bluish beneath ; on dorsum are three approximated dark olive-buff stripes (of a paler shade than the corresponding stripes on the frons) separated by slate-blue, more definitely so in front, merging somewhat posteriorly and fully on scutellum ; laterally are wide slate-blue stripes extended on to outer corners of scutellum. Thorax and scutellum clothed with rather sparse white pubescence above, pleura with denser, dark olive-buff pubescence. Chaetotaxy normal ; dorso-centrals on suture, well before line of anterior supra-alars ; the posterior notopleural, lower of the two mesopleurals, pteropleural and sternopleural bristles pale brownish, others blackish. Scutellum flat, with four bristles, the apicals the shorter ; legs dark straw-colour with black pubescence and bristles, the latter at times brownish ; thoracic and alar squamae dark olive-buff and of equal size ; halteres of same colour ; mesophragma blackish, with band of dark olive-buff and shining black below. Wings with normal venation, two costal bristles ; third vein

bare above and with a few bristles below ; upper cross-vein a little more than its own length from lower ; wing-pattern blackish tawny, *Euaresta*-like and somewhat variable in detail ; base of wing more or less hyaline ; stigma black with a yellow dot on outer half ; upper branch of apical fork of pattern sometimes isolated as a spot on wing margin, when complete (there may also be two completed hyaline spots at its base) ; the top portion of the innermost hyaline indentation in the second posterior cell may be cut off as a separate spot ; small sub-hyaline spots, one on either side of the upper cross-vein, as well as similar spots in the discal cell may also be present ; conspicuous is the broad pale bar along the third vein. Abdomen dark olive-buff, with a blackish tinge, except a more or less narrow posterior margin on each segment, generally less in the male than in the female ; clothed with dark olive-buff pubescence, except at base of abdomen ; posterior margin of fifth segment of male with row of strong blackish bristles ; sixth segment in female about one-third longer than fifth ; ovipositor broad, flattened (in dry specimens), as long as last three segments together ; shining chestnut, blackish at tip, and with blackish pubescence.

Type, male and female, and some other specimens reared from puparia found in flowers of *Gazania uniflora* at Port Shepstone, v.1926 (*H. K. Munro*).

A single male specimen from Pretoria, 2.xii.1928 (*H. K. Munro*), belongs to this same species. It was taken from a jumping spider and is rather damaged. The brownish stripes on the frons are much paler, and the legs somewhat darker than has been described.

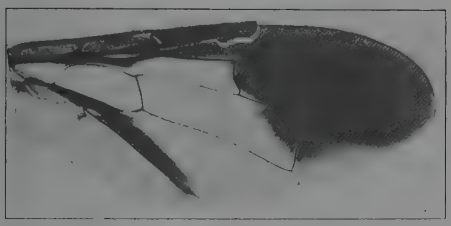


Fig. 1. *Dacus (Dacus) stentor*, sp. n.

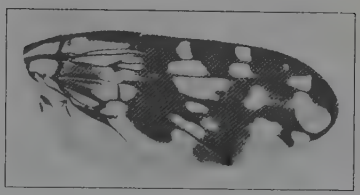


Fig. 2. *Nippia alboscutellata*, sp. n.

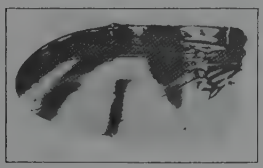


Fig. 3. *Perilampsis amazuluana*, sp. n.

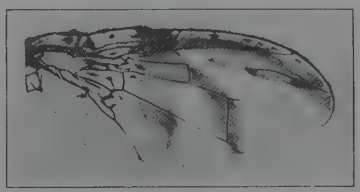


Fig. 4. *Pardalaspis scaevolae*, sp. n.

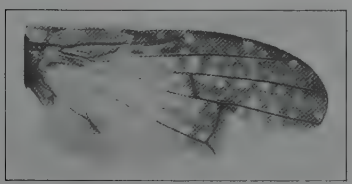


Fig. 5. *Parafreutreta pretoriae*, sp. n.

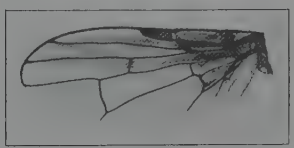


Fig. 6. *Parafreutreta bryanti*, sp. n.

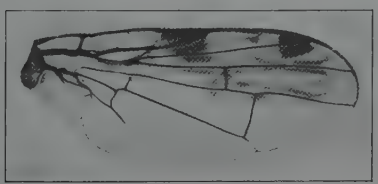


Fig. 7. *Trypanea lignoptera*, sp. n.

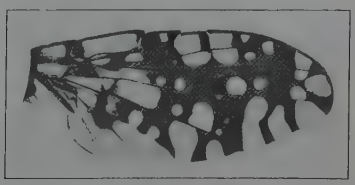


Fig. 8. *Insizwa striatifrons*, sp. n.

Wings of South African Trypetidae.

# OBSERVATIONS ON THE "FURAU" (CICINDELIDAE) OF NORTHERN NIGERIA.

By V. B. Wigglesworth, M.A., M.D.,
*Department of Medical Entomology, London School of Hygiene and Tropical Medicine.*

In the last edition of his "Entomology for Medical Officers," Colonel Alcock (1920) writes: "The 'Fura' of Nigeria is the larva of a Tiger-beetle, and is said by Dr. J. Pollard to bite the feet of passers-by, the bite being not merely painful but also causing inflammation that may spread to the inguinal glands and may last for several days." This belief is shared by many other medical officers in West Africa, and its general acceptance among the natives is emphasised by the fact that they apply the same term, "Furau," to the larva in question and to the lesion for which it is deemed responsible.

It appears, however, that the matter has not been studied experimentally, and it was largely at the instance of Dr. N. D. Dyce-Sharp, who gave me much information about the "Furau," that I took advantage of a short visit to Northern Nigeria to make some observations upon this insect. The work was done at Sherifuri, where I enjoyed every kind of assistance from Dr. W. B. Johnson and his colleagues of the Tsetse Investigation. On my return to the London School of Hygiene and Tropical Medicine, Dr. P. A. Buxton brought to my notice some correspondence which he had had from Dr. E. Le Clezio, of the West African Medical Service, who had been making similar experiments independently at Yola and had reached identical conclusions. The present account will be supplemented by reference to these experiments.

The larvae known as "Furau" doubtless belong to many different genera and species. Those with which I dealt were typical Cicindelid larvae 1·5–2·0 inches in length. They made vertical burrows of one and a half to two feet in depth and about one-third of an inch in diameter, usually in the course of native paths where the surface of the ground was smooth. The method of securing the larvae, by lowering a long grass culm into the burrow and withdrawing it slowly with the larva clinging to it, is well known to the natives. In the laboratory the larvae were maintained in pieces of glass tubing of suitable bore set vertically in "plasticine." They were able to move up and down such tubes as in their burrows, and their behaviour could be directly observed.

The larvae were fed on termites and other insects, and these they took readily enough. The stimulus for biting appears to be tactile and not visual; for they could always be induced to bite by touching the large bristles which lie along the hind margin of the head and the front margin of the prothorax, when holding an insect before them or touching other parts of the head caused no response. They seize and crush their prey between the mandibles and at the same time eject from the mouth a dark brown fluid, which is worked thoroughly into the tissues by the movements of the mandibles. If the prey be removed at this stage, it soon dies, and its tissues in the region of the wound darken rapidly and dissolve into a blackish liquid. On one occasion a larva which had its jaws embedded in the thorax of a fellow was separated from its victim, and in half an hour the thorax of the latter was almost completely divided, blackened and liquefied. It is upon this viscid solution that the larva feeds, and it does not begin to re-ingest the fluid which it has ejected until the tissues of its prey have started to dissolve.

This method of feeding is associated with certain structural adaptations in the mouth-parts. The mouth-parts of *Cicindela* larvae have been described by Schiödte (1867) and Zikan (1929). Apart from the long powerful mandibles and the simplified

maxillae, the most notable features (fig. 1) are a rigid rectangular projection of the clypeus above (epistoma), and lying against this below, a fleshy labium with rows of long bristles along the margins and with its upper surface (in contact with the epistoma) covered with a tomentum of fine hairs. The structure of this organ suggested that it might act as a sieve and prevent the ingestion of solid particles of food; and indeed such a function has been attributed (v. Lengerken 1924) to the labium in the larva of *Carabus*. But when the "Furau" feeds, the labium is alternately extended and retracted and serves as a brush which sweeps the fluid food against the epistoma and into the mouth; and immediately after retraction a peristaltic wave can be seen passing down the oesophagus.

The fluid which the larva ejects evidently contains powerful digestive enzymes which dissolve the tissues of the prey. As in the case of other Caraboid larvae, the

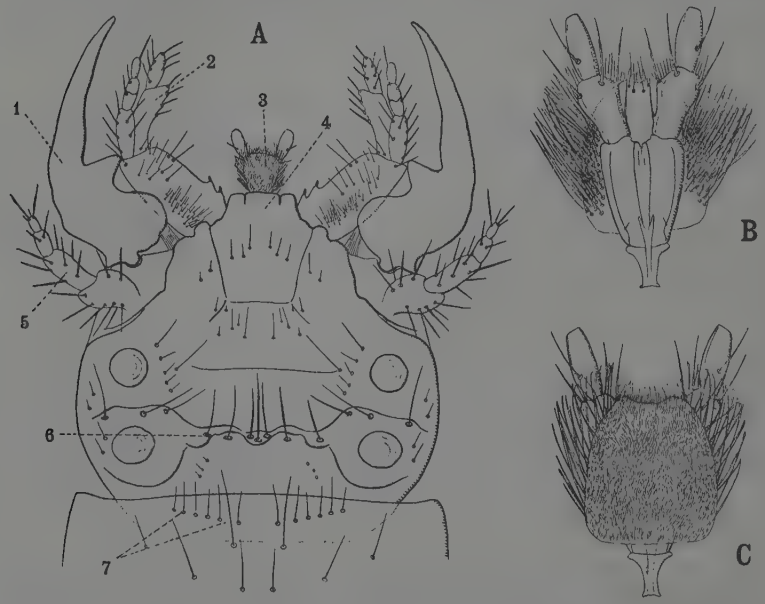



Fig. 1. A "Furau" or Tiger-beetle larva: A, dorsal view of head—1, mandible; 2, maxilla; 3, labium; 4, epistoma; 5, antenna; 6, tactile bristles on ridge at back of head, and 7, on front of prothorax. B, labium, ventral view. C, labium, dorsal view.

"Furau" possesses no salivary glands, so that this fluid is clearly a secretion of the mid-intestine. It was not possible to make a systematic study of the enzymes which it contains, but it was shown to have a pH of 6·2–6·4 and to contain an active trypsin which caused rapid clotting of calcified milk in faintly alkaline solution, and was inactivated by boiling.

The proteolytic activity of this fluid was so great that it seemed quite possible that it might cause necrosis of the skin of man and lead secondarily to abscess formation or a spreading cellulitis. This possibility was first tested with experiments on a monkey. Several areas on the leg of a monkey were shaved. Two of these areas were scarified, and fluid ejected by a "Furau" was rubbed into them. Into two more, a few cubic millimetres of the fluid were injected intracutaneously; and

on two more, larvae were induced to bite : glass tubes containing the " Furau " were inverted over the shaved areas ; the larvae were driven down to the skin and, being repeatedly poked from behind, were caused, during a period of 10 minutes, to bite the skin violently many times through the fluid which they ejected. Control experiments on scarification and intracutaneous injection were made on the opposite limb, sterile saline being substituted for the fluid from the " Furau." The treated areas were left uncovered and observed daily, but no difference between experimental areas and controls could be observed, and healing was complete in a few days. Where the skin had been bitten there was a very slight superficial induration, but no breaking down of the tissue took place.

When an attempt was made to repeat these experiments on man, the fear of the natives for the " Furau " proved to be so great that it was only with much difficulty that two volunteers were obtained who allowed themselves to be bitten on the forearm in the same manner as the monkey. The bite was quite painless, and apart from the mechanical damage to the skin, it produced no effect, although the digestive fluid was copiously discharged.

The results obtained by Dr. Le Clezio are entirely in agreement with those described above. He also allowed the larvae to bite monkeys, but " in spite of repeated attempts, failed to produce either local or general disturbances." He encountered the same difficulty in securing human volunteers, but on two occasions, when a native policeman submitted to the experiment, " the results of the bites were completely negative."

It is clear from these experiments that the bite of the " Furau " is entirely without action upon the thin skin of the arm, so that it is highly improbable that it could have any effect whatsoever upon the horny foot of the native.

Now it is well known that the larvae of tiger-beetles withdraw into their burrows on the approach of man. It would be surprising therefore if they should inflict bites upon the feet of passers-by, and indeed it is not supposed by the natives that they do so. The name " Furau " is derived from the Hausa *fura*, to blow or kindle, and enquiry of the natives revealed the fact that they supposed the " Furau " to exert its action at a distance by " blowing " on the foot. Although such a suggestion savours of superstition, it has persuaded some medical officers to the belief that the dorsal hump on the fifth abdominal segment of the larva contains a gland which discharges a poison through the spines upon its surface. Some colour is given to this belief by the fact that when the larva, removed from its burrow, is allowed to bite, the abdomen is carried forward over the head and in the violence of the movement a drop of fluid may be discharged. But this fluid comes from the anus, and the movement of the abdomen is due to the absence of the support which is normally given by the walls of the burrow. Serial sections of the fifth abdominal segment show that the " hump " contains only a mass of fat body and certain powerful vertical and oblique muscles attached to the bases of the solid spines. There can be no doubt that the orthodox view, that this hump serves merely as a mechanical aid to progression in the burrow, is the correct one.

Although it is clear from the foregoing observations that the " Furau " larva can have no relation to the " Furau " of the foot, yet the latter remains a definite clinical entity, characterised by its seasonal incidence just before the onset of the rains and its resistance to healing. The condition occurs throughout Northern Nigeria, and appears to be equally common in those regions where the " bush " is not thorny, as it is in the " thorn country " of the more northerly districts.

The main interest of the experiments lies, however, in the light which they throw upon the mode of nutrition of tiger-beetle larvae. These represent yet another example of extra-intestinal digestion among insects. The whole subject of extra-intestinal digestion is reviewed by v. Lengerken (1924), who showed that this mode of nutrition is practised by the larva of *Carabus* as well as by the adult beetle as described

by Jordan (1910), and he predicted that the larvae of Cicindelids would probably be found to feed in the same manner. The blackening of the tissues during digestion, as described above, occurs also in the case of the larva of *Carabus* and the larva of *Dytiscus* (Portier 1909). In these cases a toxic principle (apparently a neurotoxin) is present in the fluid. This has not been demonstrated in the " Furau," but the rapidity with which the prey succumbs suggests that here also some such principle is present.

*Summary.*

In the " Furau," or Tiger-beetle larva of Nigeria, the digestion of the prey is mainly extra-intestinal. A dark brown slightly acid fluid, which is actively proteolytic and causes blackening of the tissues, is ejected from the intestine of the larva and dissolves the tissues of the prey. The resulting fluid is swept towards the mouth by the labium and re-ingested.

The bites of the larvae had no effect upon the skin of a monkey or of man, and there is little doubt that the larvae have no relation to the inflammatory lesion of the foot of man, which also is called " Furau " in Northern Nigeria.

*References.*

Alcock, A., 1920. Entomology for Medical Officers.—London.

Jordan, H., 1910. Ueber " extraintestinale " Verdauung im allgemeinen und bei *Carabus auratus* im besonderen.—Biol. Centralbl., xxx, pp. 85–96.

v. Lengerken, H., 1924. Extraintestinale Verdauung.—Biol. Centralbl., xliv, pp. 273–295.

Portier, P., 1909. Recherches physiologiques sur les insectes aquatiques.—C.R. Soc. Biol., lvi, pp. 379–382.

Schiödte, J. C., 1867. De metamorphosi eleutheratorum observationes.—Naturhist. Tidsskr., iv, pp. 415–420.

Zikan, J. J., 1929. Zur Biologie der Cicindeliden Braziliens.—Zool. Anz., lxxxii, pp. 269–414.

# A NEW SPECIES OF *MICROSTIGMUS* (HYM. SPHEGID.).

By Rowland E. Turner, F.Z.S., F.E.S.

**Microstigmus myersi,** sp. n. (fig. 1).

♀. Nigro-aenea, nitida; mandibulis, antennis (articulo apicali excepto), tegulis pedibusque, luteis; alis hyalinis, iridescentibus; venis fuscis, basi luteis. Long. 3·5 mm.

♀. Antennae short, the first joint of the flagellum longer than the second, which is a little longer than broad, joints 3–9 as broad as long, the two apical joints distinctly longer, the apical joint somewhat thickened and longer than the penultimate. Clypeus convex, with a low longitudinal carina, produced into a point at the apex. Eyes almost parallel on the inner margin, without marginal carinae, reaching

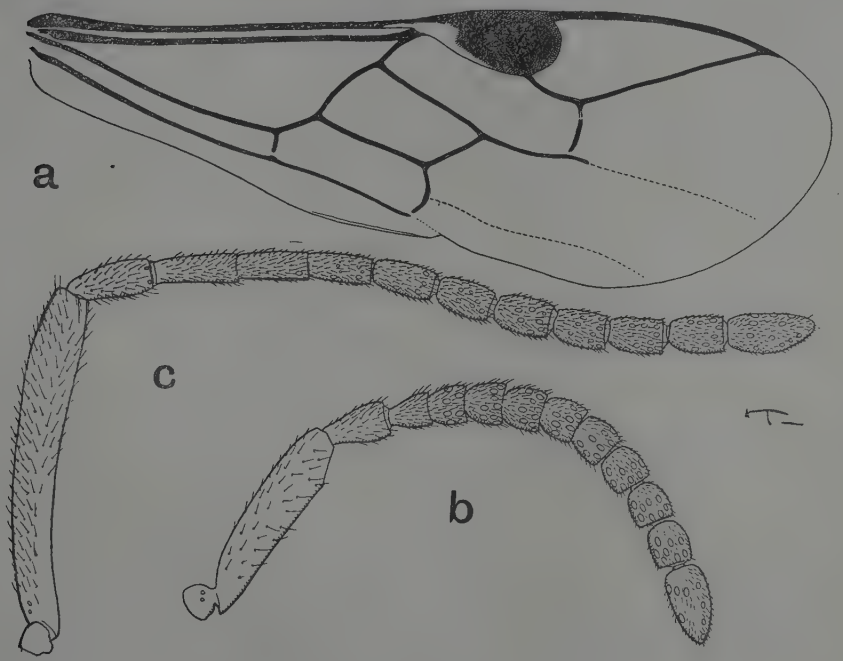



Fig. 1. *Microstigmus myersi*, sp. n.: *a* and *b*, forewing and antenna. Antenna of *M. theridii* shown at *c*.

the base of the mandibles. Head broader than the mesonotum by one quarter, narrowed behind the eyes, posterior ocelli separated from each other by a distance less than the diameter of one ocellus. Head and thorax shining, closely, but microscopically, punctured; pronotum strongly narrowed anteriorly, depressed anteriorly and margined by a low transverse carina; scutellum with a crenulated groove anteriorly. Median segment with two carinae on each side converging towards the apex, the space between the carinae transversely striated. Abdomen smooth and shining, subpetiolate; no pygidial area. Neuration as in *M. theridii*, Dücke, the type of the genus which occurs in the same locality.

TRINIDAD : 10.i.1929 (*J. G. Myers*).

Differs from *M. theridii* in the much shorter antennae, with different proportion of the joints ; also in colour and the much stronger sculpture of the median segment. In *M. theridii* also the eyes are widely separated from the base of the mandibles.

Dr. Myers writes : " The Pteromalid associated with the Collembola is indubitably a parasite of *Microstigmus*. The parasite eats up the stored Collembola, but I am not certain at what stage the host egg or larva is devoured. I have found one Sminthurid among the prey, but most are Entomobryids. I am exceedingly interested in Dücke's remarks on *Microstigmus*. He has evidently been misled by a bad guess of Goeldi. The nest is woven closely of plant fibre and suspended by a long thin thread from the underside of a leaf, very much like an egg-bag of a Theridiid spider, though I must confess I was not struck with the resemblance before. You will note Dücke does not record the presence of any spiders themselves. The new species has distinct habits. The nest is suspended under banks and tree roots in dense forest, and while it resembles that of *M. theridii* in shape, it has numerous earth pellets incorporated in the walls."

# A NEW SPECIES OF *OLIARUS* (HOM., CIXIID.) ON COCONUT PALMS.

By F. Muir.

**Oliarus cocosivora,** sp. n. (fig. 1).

Male: length, 3·5 mm.; tegmen, 4 mm.

Length of vertex along lateral margin twice the width at base; the areolets reaching nearly to middle of vertex; base angularly emarginate; a distinct, fine carina down middle of basal half. The median frontal carina forked at base. The fine carinae of mesothorax distinct. The fork of Sc+R slightly more distad than fork of Cu; the fork of M1, 2 slightly more basad than fork of M3, 4. The genitalia are figured. The anal segment a little longer than wide. The aedeagus armed with large spines.

Dark chocolate brown, which, owing to the presence of fine waxy powder, often has a bluish tint; the labium and carinae of frons lighter, the antennae, tegulae, carinae and hind margin of pronotum, the posterior margin of mesonotum, the posterior margin of abdominal segments yellow or light brown; legs light brown. Tegmina light brown with a colourless band across middle reaching from the costa to the hind margin and extending from the fork of Sc + R to the node; the basal cell and a small spot at base of costal cell colourless; veins same colour as membrane; granules very fine. Wings hyaline, fuscous over apical portions of Sc. R and M cells.

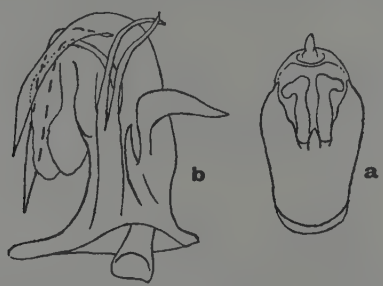



Fig. 1. *Oliarus cocosivora*, sp.n.: *a*, pygofer, full view; *b*, aedeagus.

Female: length, 4 mm.; tegmen, 5·4 mm.

Vertex slightly broader than in male and the areolets also shorter. Otherwise in build and in colour similar to male. Pygofer twice as broad as long; anal segment nearly half the width of pygofer and about as long as pygofer, broadest at base; genital styles hardly as long as the pygofer.

Malaya: Klang, 5 ♂♂, 11 ♀♀, xi.1926 (*G. H. Corbett*—no. 3400), ex *Cocos nucifera*.

# THE ASIATIC AND AFRICAN SPECIES OF THE GENUS *ELASMUS*, WESTW. (HYM., CHALCID.).

By Ch. Ferrière, D.Sc.,
*Senior Assistant, Imperial Bureau of Entomology.*

Up to 1909, the date of publication of the volume on Chalcididae in the Genera Insectorum, the genus *Elasmus*, Westw., was considered to be distributed only in Europe and America. In his list of species Schmiedeknecht mentioned only a single Asiatic species, *E. anticles*, Walk., from India, and no Australian or African species. At that date two other oriental species were already known, the one described, but not named, by Zehntner from Java (1900), and the other from the Philippine Islands, *E. philippinensis*, Ashmead (1904).

Since then, several other species have been found in South Asia: Crawford described four species from the Philippine Islands (1910 and 1914), Cameron two species from India and Borneo (placed in the genus *Cyclopleura*, Cam., 1913), Gahan one species from the Philippine Islands (1920) and another from Java (1922), and Rohwer two species from India (1921). In Australia fifty-nine species have been named by Girault from 1912 to 1922; unfortunately the descriptions are generally very short, and the absence of a table of determination since 1912 makes their study and comparison with other species very difficult. In Africa, beside three species described by Masi (1917) from the Seychelles, not a single species had yet been found.

From the material received by the Imperial Bureau of Entomology we are now able to add to this list four new species from Central Africa and four from Asia. This shows that the genus *Elasmus* is generally distributed all over the world, but that only a small number of its species is known. It is in order to facilitate the study of other species that these notes are published in the hope that it may be possible to complete them later.

*Morphology.*—The genus *Elasmus*, Westw., is easily distinguished among other genera of the Chalcidoidea by the elongate form of the body and especially of the abdomen, which is pointed, flat or depressed above and carinate below; by the narrow wings with a very long marginal vein and a very short radius; and by the specially developed hind legs with their very broad and flattened coxae covering the sides of the propodeon and of the basis of the abdomen, broad femora, and very long and slender tarsi.

We have here, perhaps, one of the most uniform genera of Chalcids, and the species are so alike in form and structure that it is difficult to find distinct morphological characters to separate them. The principal characters are, in our opinion, the disposition of the hairs on the hind tibiae, the relative length of the antennal joints and of the abdominal segments, the proportion between length and breadth of the mesonotum, and the disposition of the ciliae at the basis of the forewing. Other characters mentioned in the descriptions, such as the punctation on the head, the structure of the scutellum, propodeon, pleurae and legs, the form of the postscutellum, etc., vary so little that it is difficult to find distinct specific differences in them.

In the absence of good morphological characters, we must usually take into consideration the coloration of the body and legs. This coloration, which seems generally well fixed in series of specimens of the same species, forms the basis of most descriptions as well as of our key; but for the determination of species, the morphological characters given in the descriptions must also be considered.

The males are even more uniform in structure and coloration. Specific differences can be found generally only in the relative length of the branches of the antennae, in the coloration of the legs, and in size. It is, therefore, almost impossible at the present to identify a species by the males only.

*Biology*.—The species of *Elasmus* are parasitic upon caterpillars of small moths; some species are, however, also known to be hyperparasites. Generally, so far as is known, the female parasite searches specially for a caterpillar that is just about to pupate (some of them may have already begun or even completed their cocoons); they more or less paralyse the host by a sting, and then deposit a few eggs beside it.

The larvae of *Elasmus* feed as ectoparasites, sucking their host externally, and then change into naked pupae. The development from egg to adult is often very rapid, and there may be many generations in the year.

Economically it is an important genus as it attacks many very destructive moths and contributes to a large extent to their control. Practically, however, its utility seems in many cases to be restricted by the fact that caterpillars are only attacked just before pupation, and that the female parasite has only a few victims as her eggs are laid in clusters.

**1. Elasmus hutsoni,** sp. n.

♀. Black with bluish-green shine on head and thorax; scutellum bronze, propodeon shining blue-green; postscutellum quite white. Abdomen aeneous, shining violet at the basis, reddish-yellow below the first four segments, the reddish-yellow reaching to the sides of the 3rd and 4th segments; seen from above, the abdomen seems black with two yellow spots on the sides of the 4th segment. Antennae brown, the scape yellow. Legs pale yellow; the inferior half of the middle and hind coxae, the middle femora except at the base, and the apical two-thirds of the hind femora, blackish with green shine.

♀. *Head* small, narrower than the thorax, with a strong frontal punctation. Antennae rather long, the funicle joints almost three times longer than broad, the 1st a little longer than the scape; pedicellus only a little longer than broad. *Thorax* narrow, the mesonotum longer than broad, covered with small clear ciliae; scutellum slightly shagreened, with the four ciliae long and strong, the posterior ones reaching the basis of the abdomen. *Wings* hyaline, with a small cloud under the stigma; though long and narrow, they do not reach the tip of the abdomen; postmarginal nerve twice as long as the stigma; base of the wing with only one longitudinal row of hairs, the ciliation on the disc beginning only under the base of the marginal nerve. *Legs* with the femora and the hind coxae finely striate; the ciliae on the hind tibiae arranged in three waved lines more or less parallel from the base to the tip of the tibiae; on the middle tibiae and on the tarsi they form straight longitudinal rows. *Abdomen* elongate, about 1·5 times as long as head and thorax together. First segment large, narrowed behind, the following segments compressed from the sides, very narrow seen from above; 2nd and 3rd segments short, transverse, 4th as long as broad, 5th–7th much longer than broad. Ovipositor little protruding.

*Length*, 3·1 mm.

Ceylon: Pelmadulla, 2 ♀♀, 20.iii.1918 (*J. C. Hutson*).

*Host*. Bred from cases of the Tea Bagworm, *Psyche albipes*, Mo.

Type deposited in the British Museum.

**2. Elasmus bellus,** Masi

*Elasmus bellus*, Masi, Novitates Zoologicae, xxiv, 1917, p. 199.

♀. Body black with green and bronze shine; abdomen brownish-aeneous above, with the 1st and 5th segments slightly reddish-yellow, quite reddish below, except

the tip. Postscutellum white, black at the base. Antennae pale brown, scape and pedicellus yellow. Wings slightly dusky at the middle. Legs entirely pale yellow, only the upper part of the hind coxae black, and hind femora with a black stripe above and a brown transversal band after the middle.

♀. *Head* as broad as thorax, with the punctation well marked. Antennae with the pedicellus short and narrow, the funicle joints more than twice as long as broad, the club as long as the two preceding joints together. *Thorax* shagreened, the mesonotum as long as broad, covered with pale ciliae; propodeon more shining. *Wings* narrow, elongate, ciliate from the base of the marginal vein and with only one row of ciliae at the basis of the wing. *Legs*: the rows of hairs on the hind tibiae arranged in waved lines, more or less parallel. *Abdomen* not longer than head and thorax together, but narrower; the segments transverse except the 1st and 6th. Ovipositor as long (beyond the tip of the abdomen) as the 7th segment.

*Length*, 2·2 mm.

Type locality: SEYCHELLES Is., Silhouette.

*Host* unknown.

This short redescription has been made from the type, which is in the British Museum.

**3. Elasmus brevicornis,** Gahan

*Elasmus brevicornis*, Gahan, Treubia, iii, 1922, p. 50.

Type locality: JAVA, Buitenzorg.

*Host*: *Erionota thrax*, L.

The following material has been received by the Imperial Bureau of Entomology, and agrees with the description of the type: INDIA: Dehra Dun, U.P., 20 ♀♀, 5 ♂♂, 5–25.xi.1927 (*S. N. Chatterjee*), parasitic on larva of *Hapalia machaeralis*, Wlk., on *Tectona grandis*. MALAYA: Kuala Lumpur, 5 ♀♀ (*G. H. Corbett*), from *Psara stultalis* on *Pogostemon patchouli*, and 4♀♀, 29 ♂♂, 7.xii.1923, 19.xii.1923, 5.i.1924 (*G. H. Corbett*), parasitic on larva of *Sylepta derogata*, F.

**4. Elasmus philippinensis,** Ashm.

*Elasmus philippinensis*, Ashmead, Proc. U.S. Nat. Mus., xxviii, 1904, p. 138.

Type locality: PHILIPPINE Is., Manila.

*Host* of type unknown. Gahan (Philipp. Journ. Sc., xxvii, 1925, p. 83) gives as host the Hesperiid, *Erionota thrax*, L. According to Woodworth it is also a parasite, in the Philippines, of *Sylepta derogata*, F.

Other specimens placed in this species are from MALAYA, Kuala Lumpur, 6 ♀♀, 27.v.1925 (*G. H. Corbett*).

*Host*: *Lamprosema diemenalis*, Guen.

Ashmead's description is very short, but can be completed by the note given by Crawford at the end of his description of *E. elegans*, in which it is said—"That species (*E. philippinensis*, Ashm.) is much smaller, has the joints of the funicle much shorter, the hind coxae except extreme apices dark, the hind femora entirely dark, etc." Judging by these descriptions, size, coloration, shortness of antennae, this species stands very near to *E. brevicornis*, Gahan, from which it differs specially by the middle of the abdomen being more reddish, the apex of hind coxae yellow, and the smaller size.

In our specimens from Malaya, the base of the hind femora is also more or less yellow, whereas our *E. brevicornis* from Malaya are larger and have the coxae and femora quite black.

**5. Elasmus albomaculatus,** Gahan

*Elasmus albomaculatus*, Gahan, Philippine Journ. Sc., xvii, 1920, p. 347.

Type locality: PHILIPPINE Is., Manila.

*Host*: *Acrocercops* sp. (Gracillariidae) on *Caesalpinia pulcherrima* (L.), Sw.

**6. Elasmus hyblaeae,** sp. n.

♀. Black with greenish shine, more bluish on head, on scutellum, and on the propodeon and base of abdomen; rest of abdomen aeneous. Postscutellum quite white. Antennae brown, the scape yellow. Legs with dark coxae and femora; the tip of anterior femora, the tibiae and tarsi pale yellow; hind coxae above with bluish shine.

♀. *Head* with the frontal punctation well marked, but small. Antennae not very elongate, the funicle joints about twice as long as broad; pedicellus shorter than 1st funicle joint, but almost as long as 2nd; club somewhat shorter than the two preceding joints together. *Thorax*: Mesonotum and scutellum finely shagreened; the mesonotum a little broader behind than its median length, covered with brownish hairs; scutellum broader than long, with the four ciliae moderately long; post-scutellum short; propodeon smooth and shining. *Wings* hyaline, entirely ciliate, except for a hairless line near hind border, overreaching tip of abdomen. *Legs* with hind femora oval, relatively short, about twice as long as broad; ciliae on hind tibiae black, arranged in regular lozenges. Hind coxae and femora very finely striate. *Abdomen* little longer than head and thorax together, the segments transverse except the 1st and the 6th; ovipositor a little protruding.

*Length*, 1·7 mm.

INDIA: Aravallica, Nilambur, Madras, 1 ♀, 23.viii.1925 (*S. N. Chatterjee*).

*Host*: Parasitic on second instar of *Hyblaea puera* larva.

Type deposited in the British Museum.

This species is related to other dark species, in particular to *E. johnstoni*, but may be distinguished by its smaller size, quite clear tibiae and tarsi, and longer joints of antennae.

**7. Elasmus johnstoni,** Ferr.

*Elasmus johnstoni*, Ferrière, Bull. Ent. Res., xx, 1929, p. 258.

Type locality: AFRICA, British Sudan, Wad Medani (*H. B. Johnston*).

*Host*: *Platyedra gossypiella*, Saund.

Other examples of this species have also been received from: BRITISH SUDAN: Wad Medani, 13 ♀♀, 1 ♂, 14.iii.1927 (*H. B. Johnston*); Kamlin, 2 ♀♀, 12.ii.1928 (*H. W. Bedford*); Shendi, 2 ♀♀, 1.xii.1928 (*J. W. Cowland*); Tokar, 3 ♀♀, 23.xii.1928 (*H. W. Bedford*).

*Hosts*: Bred from *Earias insulana*, Boisd.; and obtained from bolls of *Abutilon* sp.

INDIA, Punjab, Lyallpur, 2 ♂♂, 29.xi.1923, 3 ♀♀, 1 ♂, 30.x.1927 (*U. Bahadur*).

*Hosts*: *Platyedra gossypiella*, Saund., and *Earias* spp.

The Indian and African specimens are alike and belong without doubt to the same species, which is thus widely distributed as a parasite of cotton bollworms.

We have also 2 ♀♀, 1 ♂, obtained in Br. Sudan from *Earias insulana*, that are much smaller (1·5–1·6 mm.) and have a reddish coloration of the body, but for the rest are identical wtth this species. We have probably here only some abnormally small and discoloured specimens.

**8. Elasmus masii,** sp. n.

*Elasmus* sp., Masi, Novitates Zoologicae, xxiv, 1917, p. 200.

Type locality: SEYCHELLES Is., Silhouette and Mahé.

*Host* unknown.

This species, of which the type and cotypes are in the British Museum, is very similar to certain European forms; but the Palaearctic species are still too little known to allow a comparison.

As it differs from every other African and Asiatic species by its dark brown tibiae and tarsi, the tibial spurs alone being pale yellow, we think it is better to give this species a name. But it will be necessary to take it again into consideration, like many other exotic species, when the European ones are revised.

**9. Elasmus indicus,** Rohw.

*Elasmus indicus*, Rohwer, Ann. Mag. Nat. Hist. (9), xii, 1921, p. 123.

Type locality: SOUTH INDIA, Coimbatore.

*Host*: specimens labelled "parasitic on Coccids on *Acacia*."

This species has been obtained in India by Ramachandra Rao and M. C. Cherian (see under *E. nephantidis*) from young larvae of *Diaphania* (*Margaronia*) *indica*. The authors add that it is also found attacking *Sylepta derogata*. When in relation with Coccids, it is probably parasitic upon the predacious larvae of *Eublemma*.

**10. Elasmus nephantidis,** Rohw.

*Elasmus nephantidis*, Rohwer, Ann. Mag. Nat. Hist. (9), xii, 1921, p. 123.

Type locality: SOUTH INDIA, Coimbatore.

*Host*: *Nephantis serinopa*, Meyr., on Palm.

The life-history of this species has been well studied by Y. Ramachandra Rao and M. C. Cherian (Yearbook Dept. Agric., Madras, 1926, 1927, pp. 39–50).

Specimens of this species are in the British Museum, and we have also a female from Malaya, Sudang (*G. H. Corbett*). It can be distinguished from other species by its coloration and by the yellow spots on the mesonotum near the tegulae. The only species with which it could be confused is *E. albomaculatus*, Gahan, which has also the same yellow spots. From that species it differs specially by the reddish coloration at the basis of the abdomen below; but as this coloration is often slight in extent and may be hidden by the hind coxae, the species may be easily confused.

**11. Elasmus homonae,** sp. n.

♀♂. Dark greenish on head and thorax, more shining on propodeon and base of abdomen. Postscutellum quite white in ♀, black at the base in ♂. Antennae dark brown, scape and pedicellus below pale yellow. Front legs pale yellow except base of femora; middle legs with black coxae and femora, except base and end of the latter; hind legs with the coxae quite black and only the terminal two-thirds of the femora dark. In the ♂ the legs are almost white with the hind and middle coxae and femora dark, except a white spot at the tip of the middle femora, and the basal fourth of the hind femora which are white. Abdomen dark aeneous above with a reddish transversal band at the end of the 1st segment and sometimes also, less conspicuous, on the 3rd segment; below almost quite red with a black tip. The abdomen of the ♂ quite black.

♀. *Head* almost as broad as thorax, with punctation strong but apart. Antennae inserted below middle of face; scape shorter than the two following joints together; pedicellus almost as long as 2nd funicle joint; funicle joints strong, about twice as

long as broad, the 1st a little longer than the two others ; club somewhat shorter than the two preceding joints together. *Thorax* finely shagreened ; mesonotum as broad as long, the ciliae close together and greyish ; scutellum almost smooth ; post-scutellum large, triangular, projecting posteriorly further than the middle of the propodeon ; propodeon smooth. *Wings* hyaline, almost entirely ciliate, the hairless line near the hind border short and narrow. *Legs* : middle and hind coxae and femora finely striate ; hind tibiae with hairs arranged in diamond-shaped lozenges. *Abdomen* oval, elongate, little longer than head and thorax united, narrower than thorax ; the segments transverse, except 1st and 6th.

♂. Very similar to the female, but smaller. Abdomen as long as thorax. It differs specially in the coloration of the body and the form of the antennae, where the three branches reach the base of the club.

*Length*, ♀ 2·2 mm., ♂ 1·3–1·8 mm.

Ceylon, 3 ♀♀, 2 ♂♂, 1927 (*S. S. Light*).

*Host* : *Homona coffearia*, Nietn., on tea.

Type deposited in the British Museum.

This species is related to *E. nephantidis*, Rohw., from which it differs, apart from the absence of white spots near the tegulae, in the following characters: the abdomen is almost quite red below, except at the tip; in *nephantidis* it is only red at the base below, near the hind coxae ; the hind femora are white at the basal third ; in *nephantidis* they are white only more or less at the extreme base; the 2nd and 3rd funicle; joints are shorter than the 1st, in *nephantidis* they are all of about the same length. *E. indicus*, Rohw., is clearly smaller and has quite black hind femora.

**12. Elasmus anticles,** Walk.

*Elasmus anticles*, Walker, Ann. Mag. Nat. Hist., xvii, 1846, p. 181.

The short description of the type is as follows :—

" ♀. Viridis, antennis pedibusque piceis, alis limpidis.

" Body green ; head very short ; antennae piceous, shorter than the thorax ; thorax convex, coarsely punctured, podeon not apparent ; abdomen lanceolate, twice the length of the thorax, depressed above, keeled beneath, decreasing in breadth from the base to the tip ; oviduct subexserted ; legs piceous, long, slender ; wings limpid, nervures fuscous ; ulna nearly twice the length of the humerus ; radius short, cubitus not more than half the length of the radius, stigma very small."

*Length*, 2 mm.

Type locality : India, Bombay.

*Host* : " *Tinea* " sp.

**13. Elasmus elegans,** Crawf.

*Elasmus elegans*, Crawford, Philippine Journ. Sc., ix, 1914, p. 461.

Type locality : Philippine Is., Los Baños.

*Host* unknown.

**14. Elasmus fumipennis,** Cam.

*Cyclopleura fumipennis*, Cameron, Ind. Forest Rec., iv, 1913, p. 97.

♀. Black with greenish shine, abdomen more aeneous ; postscutellum and two spots on sides of mesonotum near tegulae white. Abdomen reddish below at the base. Antennae dark, scape and pedicellus yellow ; mandibles reddish. Legs with median coxae black, anterior and hind coxae only black at the base, yellow on the inferior

half; all trochanters yellow; anterior femora yellow with a black stripe above; middle femora quite black; hind femora with a large yellow spot at the base; tibiae and tarsi yellow with black hairs. Wings hyaline at the base, strongly infumate, almost black, on the terminal half.

♀. *Head* small, but as broad as thorax; the punctation not deep and scattered. Antennae rather long, the pedicellus short, little longer than broad; the three funicle joints subequal in length, about 2·5 times as long as broad; club shorter than the two preceding joints together. *Thorax*: Mesonotum dull, covered with small ciliae, a little longer than broad; scutellum finely shagreened, almost smooth; postscutellum triangular, projecting over the propodeon; propodeon finely shagreened, but more shining than scutellum. *Wings* elongated, not reaching to tip of abdomen; they are entirely ciliate, with a hairless line near hind margin at basis. *Legs* with coxae and femora finely striate; the ciliae on hind tibiae arranged in regular lozenges. *Abdomen* narrow, elongated, pointed at apex, longer than head and thorax together; segments transverse, except the 1st, 5th, 6th and 7th, which are longer than broad. Ovipositor slightly projecting over end of abdomen.

*Length*, 3·5 mm.

BORNEO: Kuching (*J. Hewitt*).

*Host* unknown.

Redescribed from the type in the British Museum.

### 15. **Elasmus zehntneri**, sp. n.

*Elasmus* sp., Zehntner, Meded. v. h. Proefstation v. Suikerriet West Java, no. 46, 1900, p. 1.

Zehntner has given a long and very good description of this species, together with a coloured drawing of the adult and black and white drawings of the antennae of female and male. It is thus possible to have a clear idea of this insect and to see that it is really a new species. To facilitate the study of this species we give here a short résumé of the description.

♀. Head and thorax black with greenish shine; abdomen orange, the two last segments, lines on the sides of the 2nd and 3rd segments, and triangular spots on the side of the 4th and 5th segments, black. Antennae yellow, the 2nd joint black above. Legs pale yellow, almost white, coxae and femora of the middle and hind legs black on upper margin, the tarsi somewhat brown. Wings hyaline, with yellow nerves.

♀. *Head* short, narrower than thorax. *Thorax* long and narrow, flattened above. Mesonotum covered with fine ciliae. Scutellum almost quadrate, longer than broad. Propodeon broad at the basis, concave behind, smooth and shining. *Abdomen* elongated with the form of a triangular pyramid. The ovipositor projects very little beyond tip of the abdomen. Antennae with ten joints; the 1st (scapus) flattened and enlarged below; the 3rd (annellus) very short, oblique; the 4th (2nd annellus) also very short, but longer than the 3rd; the 5th (1st funicle) three times as long as broad; the two following gradually shorter and broader, the three last forming a club. *Legs* with the coxae broadened very much; femora less broadened, tibiae short, and tarsus very long in the hind legs. Hind tibiae with lozenge-shaped lines covered with short rigid hairs. *Wings* with marginal nerve longer than submarginal, stigmal nerve very short; at basis of wing two narrow hairless parts.

♂. Smaller than female; abdomen paler yellow and the triangular black spots on the sides of 2nd–5th segments broader; on 5th segment the spots join above so that only the hind border remains yellow. Antennae with long ramelli on 4th, 5th and 6th joints; 7th joint long, as long as two-thirds of 3rd ramellus; club narrow.

*Length*, ♀ 2·8–3 mm., ♂ 2–2·25 mm.

Type locality: WEST JAVA.

*Host*: *Scirpophaga intacta*, Sn., a sugar-cane borer.

**16. Elasmus claripennis,** Cam.

*Cyclopleura claripennis*, Cameron, Ind. Forest Rec., iv, 1913, p. 92.

*Elasmus colemani*, Mahdihassan, Jn. Sc. Ass. Maharadjah's Coll., i, 1923, p. 69.

*Elasmus claripennis* (Cam.), Ferrière, Bull. Ent. Res., xix, 1928, p. 171.

Type locality: INDIA, Dehra Dun.

*Host*: Bred with *Tachardia lacca*. The specimens described by us in 1928, received from Bengal, Nankom (*C. S. Misra*), had been reared from *Eublemma amabilis*, Moore, a Noctuid predacious on *Tachardia lacca*.

Mahdihassan mentions this species under the name *E. colemani* as a parasite of *Eublemma amabilis*, M. He has bred from the same host another *Elasmus*, which he calls *E. claripennis*, Cam., and which differs in having on the hind tibiae "two irregularly shaped rows of hairs not forming any cells." This last species is very probably distinct and new, and is related to *E. hutsoni* in the first group of the table.

**17. Elasmus ceylonicus,** sp. n.

♀. Body black with green shine. Antennae yellow, scape paler. Scutellum with a transversal yellow band along hind margin. Postscutellum yellow with base black. Abdomen reddish, the base of 1st segment, the last segments from end of 5th, and spots on sides of the median tergites, black. Legs pale yellow with dark coxae and femora; tip of front coxae and of all femora, as well as the base of the hind femora, yellow.

♀. *Head* as broad as thorax, strongly punctate. Antennae short; scape a little shorter than the two following joints together; pedicellus elongate, almost as long as funicle joints; the latter all about the same length, 1·5 times as long as broad; club as long as the two preceding joints together. *Thorax*: Mesonotum somewhat broader than long, covered with dark ciliae; scutellum shagreened; postscutellum forming an elongate triangle, the translucid part projecting over the propodeon; propodeon smooth and shining. *Wings* elongate, entirely ciliate from the base, at rest overreaching tip of abdomen. *Legs* with the sides of coxae and femora very finely striate; hind tibiae with the ciliae forming well-marked lozenges. *Abdomen* smooth, the 1st segment the broadest, the sides converging from there to the tip. The 2nd to 5th segments transverse. Ovipositor projecting a little beyond tip of abdomen.

*Length*, 2 mm.

CEYLON: Pelmadulla, 2 ♀♀, 20.iii.1918 (*J. C. Hutson*).

*Host*: From cases of *Psyche albipes*, the Tea Bagworm.

Type deposited in the British Museum.

Bred at the same time as *E. hutsoni*, but is a very distinct species. It resembles somewhat *E. zehntneri*, from Java, but differs in having a transverse yellow band on the scutellum and almost black hind coxae and femora.

**18. Elasmus eximius,** Masi

*Elasmus eximius*, Masi, Novitates Zoologicae, xxiv, 1917, p. 199.

♀. Black, with greenish shine; cheeks, mouth, sides of pronotum and two points just behind on the mesonotum, a spot on the upper part of mesopleurae, scutellum

(except a dark spot behind), and postscutellum, reddish-yellow. Abdomen reddish-orange, black from the 6th segment and with two small dark spots on the sides of 3rd and 4th segments. Antennae reddish-yellow, brownish above. Wings slightly infuscated. Legs yellow; only the middle coxae, the upper part of the hind coxae, and lines on the upper and lower margins of hind femora, black; these lines on hind femora broadening behind to form a transversal stripe near the tip.

♀. *Head* as broad as thorax; punctation distinct. Antennae with short scape, not much longer than the 1st funicle joint, the pedicellus a little longer than broad, the funicle joints more than twice as long as broad, the club shorter than the two preceding together. *Thorax*: Mesonotum as broad as long, covered with short hairs. Scutellum almost quadrate, finely shagreened. Propodeon smooth and shining. *Wings* ciliate from base, with the hairless part rather broad near the hind margin at the base. *Legs* very finely striate on outer part of coxae and femora; hairs on hind tibiae arranged in regular lozenges. *Abdomen* a little longer than head and thorax together; 1st segment as long as broad behind, the following segments transverse. Ovipositor little protruding.

*Length*, 2·3 mm.

Seychelles Is.: Mahé, 1908.

*Host* unknown.

Redescribed from the type in the British Museum.

**19. Elasmus africanus,** sp. n.

♀♂. Black, with greenish shine, specially upon the propodeon and the upper part of the hind coxae; a narrow stripe on vertex behind posterior ocelli, a larger transversal band along hind border of mesonotum, and the tegulae, yellow. Postscutellum white with a black base. Abdomen dark; the 1st segment white at base except a black median spot; posterior margins of segments 1–5 with reddish transversal stripes more or less marked, broader at the middle than on the sides; they are sometimes confluent in the middle so that the middle of the segments may be quite reddish, but on segments 1–3 they may be also quite absent. Antennae brown, the scape white. Legs pale yellow, almost white; the base of median coxae, the hind coxae almost entirely, and a narrow line on the middle and hind femora, black. The male with head, thorax and abdomen quite black, except a narrow reddish stripe along hind margin of 1st abdominal segment; coloration of legs like that of the female.

♀. *Head* as broad as thorax, with the punctation strong but scattered. Antennae inserted near clypeus, the scape relatively long, in length equal to the combined length of the two following joints and half the third joint; pedicellus elongate, but shorter than the 2nd funicle joint; 1st joint of funicle a little longer than the 2nd and 3rd, which are about twice as long as broad; club a little shorter than the two preceding joints together. *Thorax*: Mesonotum shagreened, covered with dark ciliae, a little broader than long; scutellum very finely shagreened, almost smooth; postscutellum triangular, projecting over propodeon; the latter smooth and shining. *Wings* elongate, but not reaching to tip of abdomen; the ciliation reaches the base, but is delimited near the hind margin by a regular line of hairs. *Legs* with coxae and femora finely but clearly striate; hind tibiae with the hairs arranged in regular lozenges. *Abdomen* elongate, narrower than thorax, and a little longer than head and thorax united.

♂. Similar to female, differing only in coloration, form of the antennae, and length. Antennae with the scape a little thickened in the middle, the pedicellus triangular, the three first funicle joints short, the ramelli reaching to the base of the club. Abdomen not much longer than thorax.

*Length*, ♀ 2·9–3·1 mm., ♂ 1·9 mm.

AFRICA: Nyasaland, Karonga, 25 ♀♀, 2♂♂, 19.xi.1919 (*W. A. Lamborn*).

*Host*: From cocoons found under loose bark of *Ficus* sp.

Type deposited in the British Museum.

This African species is well characterised by its large size and by the yellow stripe along the hind margin of the mesonotum, and it can be confused with no other known species.

**20. Elasmus syleptae,** sp. n.

♀. Black with metallic shine; head with two large spots on each side of vertex near the eyes, the face, below the front ocellus, and the cheeks, yellow; antennae brown with pale scape. Thorax with a transversal stripe along hind margin of mesonotum, the tegulae, lateral and posterior margins of scutellum and post-scutellum yellowish-white. Abdomen reddish below except at tip, black above with transverse, more or less broad red stripes, on the 3rd, 5th and hind margin of 6th segments. Legs entirely pale yellow, only upper part of hind coxae and lines above and below the middle and hind femora black.

♀. *Head* small, clearly narrower than thorax, the punctation not strong and scattered. Antennae with the scape short, not longer than two following joints together; the pedicellus shorter than the funicle joints, the latter of about the same length, a little more than twice as long as broad, club narrow, shorter than the two preceding joints together. *Thorax*: Mesonotum covered with short grey ciliae, as long as broad; scutellum finely shagreened; postscutellum triangular; propodeon finely shagreened, but shining. *Wings* hyaline, ciliate to the base, with a regular row of ciliae near the hind margin, at rest not reaching to tip of abdomen. *Legs* with coxae and femora very finely striate. The ciliae on hind tibiae arranged in well marked lozenges. *Abdomen* narrow, elongate, much pointed at apex, the 2nd–5th segments transverse, the 6th and 7th longer than broad. Ovipositor slightly protruding.

*Length*, 2–2·3 mm.

AFRICA: Nyasaland, Namiwawa, 9 ♀♀, 5.iv.1915 (*C. Mason*).

*Host*: *Sylepta derogata*, F.

Type deposited in the British Museum.

This species is related to *E. africanus*, but differs, beside the characters given in the table, in its smaller size, the longer funicle joints, and in the abdomen which is here quite red below.

**21. Elasmus lamborni,** sp. n.

♀♂. Head and thorax of ♀ yellow with the following parts black: a large spot in middle of vertex between the ocelli, continued in front by a stripe reaching the basis of the antennae, pronotum above, a large median spot and two smaller side spots on the mesonotum, axillae, scutellum (except lateral and hind border), basis of postscutellum, entire propodeon, and a transverse band on mesosternum. Abdomen entirely reddish below, black above with the sides from the 4th segment and a transverse stripe at the hind margin of the 6th segment reddish. The body of the ♂ quite black with face below antennae, propleurae, upper part of mesopleurae, two spots on mesonotum near sides of pronotum, tegulae, lateral and posterior margins of the

scutellum, and posterior half of the postscutellum, yellow. Legs of ♀ entirely yellow with upper third of hind coxae and lines on the middle and hind femora black; in the ♂ the middle coxae partly, the upper half of hind coxae, and the middle of the median and hind femora, dark.

♀. *Head* as broad as thorax, the front shagreened with only few scattered points. Antennae with scape as long as the two following joints together, the pedicellus short, rounded, little longer than broad, the 1st funicle joint somewhat longer than the two others, which are twice as long as broad, club a little longer than the two preceding joints together. *Thorax*: Mesonotum a little broader than long, covered with short black hairs; scutellum shagreened; postscutellum triangular, large; propodeon finely shagreened, shining. *Wings* narrow, reaching beyond tip of abdomen, the ciliae at base more scattered than on the middle of wing, with a hairless line along the hind margin. *Legs* very finely striate, the hind tibiae narrow with the ciliae arranged in regular lozenges. *Abdomen* shorter than head and thorax united. All the segments, except the 1st, broader than long, even the 6th and the 7th which are relatively short.

♂. Similar, but smaller; abdomen as long as thorax; antennae with scape enlarged, the pedicellus rounded, as long as broad, and the ramelli very short, not longer than the club which is a little longer than the scape.

*Length*, ♀ 1·8–2·0 mm., ♂ 1·3–1·5 mm.

AFRICA: Tanganyika, Tanga, 10 ♀♀, 3 ♂♂, 8.ix.1917 (*W. A. Lamborn*).

*Host*: From Vespid nests.

Type deposited in the British Museum.

This species, probably a parasite of a moth in the Vespid nests, is well characterised by the coloration of head and thorax, by the short abdomen of the ♀ where the last segments are also broader than long, and by the specially short ramelli of the antennae of the ♂.

**22. Elasmus lutens,** Crawf.

*Elasmus lutens*, Crawford, Philipp. Journ. Sc., ix, 1914, p. 461.

Type locality: PHILIPPINE Is., Los Baños.

*Host* unknown.

**23. Elasmus ashmeadi,** Crawf.

*Elasmus ashmeadi*, Crawford, Philipp. Journ. Sc., ix, 1914, p. 462.

Type locality: PHILIPPINE Is., Manila.

*Host* unknown.

**24. Elasmus albopictus,** Crawf.

*Elasmus albopictus*, Crawford, Proc. U.S. Nat. Mus., xxxviii, 1910, p. 132.

Type locality: PHILIPPINE Is., Manila.

*Host* unknown.

*Key to Asiatic and African Species.*

1. The rows of hairs on hind tibiae arranged in waved, more or less parallel, lines ... ... ... ... ... ... ... ... ... ... 2.
   The rows of hairs on hind tibiae arranged in diamond-shaped lozenges ... 3.
2. Body elongated; abdomen longer than head and thorax together, black with a reddish spot under the first segments; middle and hind femora black-greenish, the base of the hind femora yellow ... ... 1. *hutsoni*, sp. n.
   Body shorter and broader; abdomen not longer than head and thorax, reddish below with base and last segments black; femora yellow, the hind femora with a black line above and a brown spot after the middle
   2. *bellus*, Masi
3. Antennae with the funicle joints short, not or little longer than broad ... 4.
   Funicle joints elongate, the 1st distinctly longer than the pedicel, or at least longer than broad, generally twice or more as long as broad ... ... 5.
4. Hind coxae quite black; length, 1·5 to 2 mm. ... 3. *brevicornis*, Gahan
   Hind coxae black with a yellow tip; length, 1 to 1·3 mm.
   4. *philippinensis*, Ashm.
5. Thorax black with metallic shine, only postscutellum and sometimes two spots near the tegulae yellow or white ... ... ... ... ... ... 6.
   Thorax partly yellow, at least mesonotum or scutellum with a yellow band 17.
6. Hind coxae black or only the extreme tip clear ... ... ... ... 7.
   Hind coxae yellow or at least the lower third clear ... ... ... 13.
7. Abdomen quite black ... ... ... ... ... ... ... ... 8.
   Abdomen more or less yellow or reddish, at least at basis below ... 11.
8. Two white spots on sides of mesonotum near tegulae
   5. *albomaculatus*, Gahan
   No white spots near tegulae ... ... ... ... ... ... 9.
9. All tibiae clear yellow; length, 1·5 to 1·8 mm. ... ... 6. *hyblaeae*, sp. n.
   Hind tibiae more or less darkened ... ... ... ... ... ... 10.
10. Hind tibiae and tarsi clear yellow with a large brown ring near end of tibiae
    7. *johnstoni*, sp. n.
    Hind tibiae and tarsi dark or reddish, with only tibial spurs yellow
    8. *masii*, sp. n.
11. Hind femora quite black; length, 1·5 mm. ... 9. *indicus*, Rohwer
    Hind femora more or less clear at base; length, 2 to 2·5 mm. ... ... 12.
12. Two white spots on mesonotum near tegulae ... 10. *nephantidis*, Rohwer
    No white spots near tegulae ... ... ... 11. *homonae*, sp. n.
13. Abdomen quite black ... ... ... ... ... 12. *anticles*, Walker
    Abdomen partly reddish, at least below ... ... ... ... ... 14.
14. Hind femora yellow on basal half ... ... ... ... ... ... 15.
    Hind femora quite clear or with a line or a spot on upper margin ... 16.
15. Abdomen reddish at base, above and below; mesonotum quite black; wings slightly dusky; front coxae whitish; length, 2·5 mm. 13. *elegans*, Crawf.
    Abdomen reddish only below at base; mesonotum with two white spots near tegulae; wings almost blackish at terminal half; front coxae whitish, black at base; length, 3·5 mm. ... ... ... ... 14. *fumipennis*, Cam.
16. Abdomen reddish-yellow with the tip and spots on sides of segments black
    15. *zehntneri*, sp. n.
    Abdomen black with transverse reddish stripes more or less marked on first segments ... ... ... ... ... ... 16. *claripennis*, Cam.

17. Mesonotum black, or with only a yellow stripe or spots ... ... ... 18.
Mesonotum yellow, or with black spots or lines ... ... ... ... 21.
18. Mesonotum without transverse stripe ... ... ... ... ... 19.
Mesonotum with a yellow transverse stripe along hind margin ... ... 20.
19. Scutellum black with a yellow tip; mesonotum dark; hind coxae black
17. *ceylonicus*, sp. n.
Scutellum reddish-yellow; mesonotum with two clear spots near sides of pronotum, which are also clear; hind coxae yellow on basal half
18. *eximius*, Masi
20. Scutellum black; hind coxae dark with a yellow tip 19. *africanus*, sp. n.
Scutellum with a yellow stripe along side and hind margin; hind coxae yellow with base black ... ... ... ... ... 20. *syleptae*, sp. n.
21. Abdomen black above, yellow below; three spots on the mesonotum, axillae, middle of scutellum and propodeon black... ... 21. *lamborni*, sp. n.
Abdomen yellow with black spots or only dark at base ... ... ... 22.
22. Scutellum yellow; on thorax only the axillae and two spots on sides of propodeon black ... ... ... ... ... ... 22. *lutens*, Crawford
Scutellum more or less dark ... ... ... ... ... ... 23.
23. Mesonotum with a black median longitudinal stripe; middle of pronotum, the scutellum, propodeon, and base of abdomen, also dark
23. *ashmeadi*, Crawford
Mesonotum quite yellow; only axillae, base and middle of scutellum, and spots on propodeon, on the mesopleurae, and on each side of 1st abdominal segment, black ... ... ... ... ... 24. *albopictus*, Crawford

*List of the hosts of the species of* Elasmus *dealt with in this paper.*

| | | |
|---|---|---|
| *Acrocercops* sp. ... ... ... | *E. albomaculatus*, Gahan ... | Philippine Is. |
| *Diaphania* (*Margaronia*) *indica*, Saund. | *E. indicus*, Rohwer ... | India. |
| *Earias insulana*, Boisd. ... ... | *E. johnstoni*, Ferr. ... | Africa, India. |
| *Erionota thrax*, L. ... ... ... | *E. brevicornis*, Gahan ... | Java. |
| | *E. philippinensis*, Ashm. ... | Philippine Is. |
| *Eublemma amabilis*, Moore ... ... | *E. claripennis*, Cam. ... | India. |
| *Hapalia machaeralis*, Walk. ... ... | *E. brevicornis*, Gahan ... | India. |
| *Homona coffearia*, Nietn. ... ... | *E. homonae*, sp. n. ... | Ceylon. |
| *Hyblaea puera*, Cram. ... ... | *E. hyblaeae*, sp. n. ... | India. |
| *Lamprosema diemenalis*, Guen. ... | *E. philippinensis*, Ashm. ... | Malaya. |
| *Nephantis serinopa*, Meyr. ... ... | *E. nephantidis*, Rohwer ... | India. |
| *Platyedra gossypiella*, Saund. ... | *E. johnstoni*, Ferr. ... | Africa, India. |
| *Psara stultalis*, Wlk. ... ... | *E. brevicornis*, Gahan ... | Malaya. |
| *Psyche albipes*, Mo. ... ... | *E. hutsoni*, sp. n. ... ... | Ceylon. |
| | *E. ceylonicus*, sp. n. ... | Ceylon. |
| *Scirpophaga intacta*, Sn. ... ... | *E. zehntneri*, sp. n. ... | Java. |
| *Sylepta derogata*, F. ... ... | *E. syleptae*, sp. n. ... | Africa. |
| | *E. indicus*, Rohwer ... | India. |
| | *E. brevicornis*, Gahan ... | Malaya. |
| | *E. philippinensis*, Ashm. ... | Philippine Is. |
| "*Tinea*" sp. ... ... ... | *E. anticles*, Walker ... | India. |

# NOTES ON SOME NATURAL ENEMIES OF *PLODIA INTERPUNCTELLA* AND *SILVANUS SURINAMENSIS* IN AUSTRALIA.

By J. G. Myers, Sc.D., F.E.S.,
*Imperial Bureau of Entomology.*

## Introduction.

During the first half of 1927 the writer visited the chief grape-growing districts of Australia to investigate on behalf of the Empire Marketing Board and the Commonwealth Government the insect infestation of dried fruit. The more immediately practical results of this study were published in November 1928 (E.M.B., 12, 36 pp.). On pages 20–22 of that report the question of natural enemies was briefly considered. The present notes describe certain aspects of the behaviour of these natural enemies, with special reference, in the case of the "parasites," to oviposition habits. The literature on *Microbracon hebetor*, Say (*Habrobracon juglandis*, Ashm.) has grown enormously in the last few years, and the present section on this insect makes no pretence to deal with the mass of literature upon it, nor to summarise our knowledge of its biology. Among more monographic papers on *M. hebetor* may be mentioned those of Hase (the subject at first determined in error as *Habrobracon brevicornis*) and Genieys (chiefly morphological). Showell (Jl. Dept. Agric. South Australia, xxxi, 1928, pp. 1048–1056), has recently published an account of the life-history under Australian conditions; while Schulze (1924) has described its psychology, with special reference to cleaning-habits and antennal movements. Schulze's work I have not seen.

Most of the observations here reported were made in the Mildura district of Victoria. For acknowledgments of assistance see the general report (E.M.B., 12).

## *Microbracon hebetor*, Say.

*Mating.*—Copulation was observed on a window of a shed where dried fruit was stored. The male was carried by the female, head towards hers, and abdomen bent downwards and forwards, with wings aloft, flapping vigorously. Pairing was resumed in a pill-box, but endured for only a few seconds, the female upside down on the glass, the male suspended head downwards. The male pursues the female with wings outstretched and upstretched and waving actively.

*Oviposition and associated Habits.*—Captive females were always ready to attack a *Plodia* larva, and the whole operation could be observed with ease. When the larva, in its wanderings, approached the *Microbracon*, there was a lightningly quick bending under and forward of the abdomen of the latter, and the ovipositor seemed barely to touch the prey. The larva wandered round again for some time, apparently unaffected, but presently gradually came to a standstill on the side of the box. A tap, and it fell immobile on the floor, lying on its side. Its heart was beating.

Later the wasp approached and seemed to oviposit very slowly and with great deliberation near the posterior end of the body, afterwards turning round and feeding for ten minutes at the puncture. It then wandered over the caterpillar, apparently seeking another place to pierce. The heart of the larva beat apparently normally throughout the process.

A second time the ovipositor was thrust in for three minutes and then completely or partially (I am not sure) withdrawn and inserted in or near the same spot, whence it was again withdrawn after another two minutes. The wasp then walked along a few millimetres and inserted the ovipositor again, without feeding at the recent puncture. The ovipositor was always thrust just under the curve of the caterpillar's body, so that I could not see the actual insertion. The instrument was drawn out after three minutes, and feeding at the puncture lasted one and a half minutes.

I turned the larva over and found an egg attached to the surface of the skin at the second apparent puncture, but none elsewhere. Thus at the first and third punctures there was feeding and no oviposition, while at the second point, there was an egg laid and no feeding.

The Braconid returned to the larva after half an hour and used its ovipositor near the posterior end, working for six minutes, during which time three eggs were stuck to the skin of the host ; but there was no feeding.

Such is the whole process, certain aspects of which may be considered at greater length. Paralysis of host : Sometimes the *Plodia* larva crawled with rather increased activity for some time after having been stung ; then writhed for a while on its side, without progressing, and finally, in five minutes from the stab, lay perfectly quiescent. One larva in this condition was turned over, to a normal position, and left with the wasp for three and a half hours, during which time seven eggs were laid, all on the venter. When I then tried to turn it over again, it was found that the abdominal prolegs, and especially the anal claspers, had a reflex (?) grip on the surface of the cardboard, making it difficult to turn over. It is interesting, by the way, to note that when I did turn it over, the wasp laid two more eggs, this time on the back, which was now lowermost.

The host, then, lies perfectly paralysed and flaccid, in striking contrast to the behaviour of *Calliphora* maggots stung by *Alysia manducator* ; there the effect is sudden contraction and rigidity, with rapid recovery, here gradual, extension and flaccidity and apparently no recovery, a result similar to that of malaxation by ants described later.

The following observations were made on three paralysed *Plodia* larvae kept in a pill-box without eggs. They were stung by *Microbracon* on 4th March. By the 14th there had been no movement and no defecation. The hearts of all three were beating vigorously, but at different rates ; A at 70 beats per minute, B at 33, and C at 120. Four counts of the heart-beat of normal full-fed larvae at this time gave the following figures : 73, 80, 75, 76, or an average of 76 beats per minute. Another, flaccid, larva, gathered at random, with no eggs on it, but evidently paralysed by *Microbracon*, showed a rate of 99 beats per minute.

On the 29th the heart of larva C was beating vigorously at 87 per minute. The heart-beats of the other two (A and B) were very feeble, only just perceptible. A began to turn brownish dorsally, especially at the ends.

On 1st April the heart of C was beating with *increased* amplitude, but at a rate of only 60 per minute. B's heart was just beating, but very slowly and almost imperceptibly. No movement was detectible in A. There was a slight movement—wriggling—of the last three abdominal segments of C and its head was raised slightly from the substratum.

I left the district on 4th April, when there was no perceptible beat in A or B. It was much feebler now in C, which was, however, shrinking. B looked in the best condition.

Mr. A. V. Lyon kindly continued observations a little longer. He reported that on 6th April he could still detect a heart-beat in C, but on the 10th there were signs of decay along the whole length. On the latter date B looked scarcely changed, while A, though brownish, had hardly begun to shrivel. Thus in an extreme case the heart of a *Plodia* larva may continue to beat for 33 days after paralisation.

Even where *Ephestia cautella* larvae were as plentiful as *Plodia*, the Mildura *Microbracon* females definitely preferred the latter as oviposition hosts, if they were not entirely confined to them. This was the more remarkable from the fact that *Ephestia* larvae, of the same stage and size of full-fed *Plodia* caterpillars, were readily stung and paralysed ; and the punctures sucked by the female wasps. Of course, a

large number of *Plodia* larvae are also paralysed sucked and left without oviposition ; but in the Mildura district in no case were eggs found on *Ephestia* larvae. Experiments on this preference were carried out in a small way, and served to emphasise it. Thus on 4th April a full-grown *Plodia* larva and a similar *Ephestia* were confined with a *Microbracon* female. The *Plodia* was stung and paralysed almost at once, but the *Ephestia* was not interfered with for at least two hours. It was eventually paralysed, but although kept under observation by Mr. Lyon till the 24th, no eggs were deposited upon it.

It looks very much as though the Mildura *Microbracon* constitutes a race confined to *Plodia* ; but further investigation is necessary. In Western Australia, in a packing-shed where *Ephestia cautella* was present in phenomenal numbers, I found *Microbracon hebetor* (morphogically indistinguishable from the Mildura form) parasitising it very heavily.

*Life-history.*—Seven eggs laid on 16th March, at Merbein, near Mildura, had not hatched by 5 p.m. on the 17th, but were all found to have done so by 10·30 the next morning. These were on the larva which had been turned over, as described above, during oviposition. Curiously enough the larvae feeding on the white venter were white and those on the pinkish back, a bright pink. On the 20th, spinning began. On the 29th one larva, which lay naked on the blotting-paper, without making a cocoon, pupated in this position. On the 5th, adults emerged, and mated (according to Mr. Lyon's observations, after my departure) on the next day.

Of the second lot of four eggs, laid on another larva on 16th March, two hatched at exactly the same time, while the others failed to develop. The two larvae began to spin on the 20th, as in lot 1, though the host caterpillar was not half eaten. These larvae were larger than any of the seven which fed on the neighbouring larva—in some cases more than twice as large. On the 22nd the remains of the caterpillar still seemed quite fresh, though I could detect no heart-beat. On the 23rd one of the larvae seemed to have pupated, but observation was difficult through the cocoon-walls. Adults emerged on 5th April.

**Ants.**

Not by any means to be despised as enemies of *Plodia* larvae are the ants of the genus *Iridomyrmex*, so richly represented in Australia. Especially useful are *Iridomyrmex detectus*, Sm., the "meat ant," and *I. rufoniger*, Lowne (kindly determined by Mr. J. Clark). Where fruit, as in sweat-boxes, is exposed to their visits, it may be almost completely cleared of pests.

There is often a continuous file of ants, bearing *Plodia* caterpillars, from infested stacks of fruit to a nest, in one case observed, thirteen, in another fourteen yards distant.

The following observations, unless otherwise stated, concern *Iridomyrmex detectus*. In an open fumigation-shed the ants were swarming over piles of 56-lb. boxes of sultanas which were tightly nailed up. The vast majority were carrying off plump, full-fed *Plodia* larvae. One had an *Ephestia* larva. It is difficult to see how these large ants can enter the boxes. Possibly they secure chiefly larvae that have emerged to pupate. Three ants carried freshly-killed *Plodia* moths. Pupae of *Plodia* removed by me from their cocoons were borne off almost immediately, but were ignored or merely tapped with the antennae until this was done.

A larva placed in front of a foraging "meat ant" was seized at once, with a wild rush, anywhere. The whole body of the caterpillar, as far as its writhings would allow, was then subjected to strong transverse malaxation, beginning sometimes at the tail-end, sometimes near the middle, but usually ending at the neck, where the nipping was most long-continued and severe, usually preventing all further struggling of the larva. This nipping, especially in a big larva, was sometimes continued

right down the body three or more times, when the prey was seized, usually at an end, and carried off. Some individuals stopped several times to repeat the process *en route*. The nipping was never severe enough to cause exudation, save at the anus. The ant plunged down the vertical main nest-hole with its burden. There was considerable variation when ants were offered (with forceps) a *Plodia* larva. Some took to flight ; but the majority malaxated it somewhat as above, some taking much longer than others, but all reducing it to a flabby, inert mass before carrying it away.

The struggle when a live *Plodia* moth was offered was much greater, and the method of attack, though extraordinarily energetic, both sometimes rolling over and over, seemed much less practised, far too much attention being given to the wildly flapping wings or to the after part of the abdomen. Occasionally the moth escaped and flapped away to a short distance, when the ant dashed wildly round, obviously searching frantically, and pouncing hard when the moth was found again.

It was noticeable that, while an ant subduing a larva was never in my experience molested by another ant, though occcasionally investigated with waving antennae, when a moth was the cause of struggle it was common for another ant of the same species to throw itself also on the prey, often pulling a wing or the end of the abdomen in the opposite direction to the original captor.

I did not see any signs of feeding during malaxation. The limpness of these caterpillars led Mr. Showell to remark that the ants did little good as they took only larvae which had been already paralysed by *Microbracon*.

I was interested to find, in the shed where the above observations were made, an open box of raisins that had evidently been infested with *Plodia* and cleared by the ants, which were still exploring it. In this were a few small larvae, chiefly *Ephestia cautella*. To test whether there was any preference between these two species, I procured three partially-grown larvae of *Ephestia* and offered them to the ants which were carrying off *Plodia* larvae so energetically. Curious to relate, these three larvae, though put through the usual malaxation process, were then left lying, in each case, by the original captor (three different individual ants) and even by the second, third and even fourth comers. In the course of half an hour they were finally borne away by other ants of the same species.

The malaxation seemed to take more effort than in a larger *Plodia*, and in other cases an ant which had been squeezing the neck very strongly, quite close to the head, dropped the larva, and spent some time rubbing its closed mandibles shovel-wise in the sand, right and left, as though wiping off something disagreeable.

It is possible that the above behaviour was due to the fact that the ants at that time were working a pile of boxes where *Plodia* was dominant and were specialising on this prey. To test this, four days later, in another part of the shed, where no *Plodia* or *Ephestia* were present, and the ants were collecting an assortment of other materials, I gave one a full-fed *Ephestia* larva. It was seized without hesitation, squeezed at intervals down the body, and carried off with great speed before the head and thorax were immobilised. The ant was intercepted and robbed by another, which itself met several more, leading to a scramble from which the largest (a third) ran off with the caterpillar to a nest 14 yards distant. The way lay across a dusty much-used road, but the ant set a straight course, at great speed, without deviation, nor did my shadow disconcert it.

**Cephalonomia** sp.

This minute Bethylid wasp was recognised by Dr. Waterston as identical with an undescribed species found by him in 21 samples of wheat from Western Australia, New South Wales, and Victoria. (Royal Society, Reports of the Grain Pests (War) Committee, No. 9, 1921, pp. 29, 50–52.) In the Mildura district I found it a common parasite of the saw-toothed grain-beetle (*Silvanus surinamensis*).

*Oviposition Habits.*—On 5th March I placed a female *Cephalonomia* in a tube with several full-fed *Silvanus* larvae on a lexia raisin. She assaulted one furiously, biting it on the middle of the dorsum and apparently gnawing it, for a considerable time, with legs partially straggling ; but the sting I could not detect in action. The larva at first made amazing galvanic jerks of its whole body or the abdomen alone, from side to side. The wasp seemed slightly disconcerted, but kept on gnawing. The struggles grew feebler, and presently, when the wasp left, the larva fell completely immobile, apparently paralysed. No eggs were laid. This was at 4 p.m. There was still no movement 45 minutes later.

By 4.20, five more of the larvae had been paralysed, or at least rendered immobile. One had two eggs glued longitudinally to the side of the thorax.

On the 18th March I was again unable to catch the preliminary attack or to satisfy myself that the ovipositor was used. The *Silvanus* larva was writhing frantically and varying this with galvanic lateral jerks, and the wasp running up and down, gripping here and there transversely with the mandibles. There was finally prolonged squeezing of the neck, and the larva became quite immobile.

Watching operations again, with another example a day later, I managed to see the abdomen bent under and forward at the beginning of an attack, and was practically certain that a sting was dealt, with lightning rapidity. This much was certain, that partial paralysis intervened before the wasp had really obtained a grip with the mandibles ; so the sting must have achieved the result.

When the larva was entirely immobilised, it was most comical to see the wasp seize an antenna and attempt with long and severe straining to drag the grub out of the depression on the sultana in which this was lying. It succeeded at last, with my help, and dragged the larva off the sultana to its shaded side. I moved the fruit a few millimetres. The wasp followed, with the grub slung over its shoulder, so to speak, by one antenna. It actually moved in this way the much heavier insect. I shifted the sultana several times, the wasp always following. Finally I lifted it to a position one centimetre away, and the wasp failed to find it, in spite of a long search, dragging the *Silvanus* grub with her. She finally settled down to suck the back of the grub at the base of the prothorax. The jaws were deeply buried. The abdomen was at first bent under, though no oviposition was observed ; later it was extended. After 35 minutes she ceased sucking, and, evidently uneasy in the open, with her prey, began to drag it again, without shifting the grip on its prothorax. She moved it about one centimetre, and then finally abandoned it, without laying an egg.

Paralysed larvae were not always entirely immobilised. Thus one found with a single egg attached to thorax could wave its legs very slightly, and there was a faint jerking of the tip of the abdomen on stimulation. Turned on its back, however, it could not right itself. Others could wriggle even more, but none was able to progress.

A larva paralysed on 5th March, but not oviposited on, was still alive, though motionless, on the 23rd, *i.e.*, 18 days after the event.

*Life-history in Australia.*—The egg is curved, white and semi-transparent. The shell is so thin that hatching was difficult to observe. A grub with two eggs on the side of the thorax, one on back of abdomen, and a fourth lying three millimetres away on the surface of the raisin, was found on 15th March. This loose egg shrivelled up without hatching, and the dorsally placed one was lost. The other two were apparently hatched on 17th. The host grub could still wriggle its abdomen vigorously. The next day, by 5 p.m., there was scarcely a vestige of the host, and the two larvae were spinning adjacent cocoons. They looked very pink through the as yet scanty threads ; but numbers of white spots were conspicuous, especially posteriorly. The next day the cocoons were complete, and were not unlike those of *Microbracon*, but much smaller of course, and of a more rounded shape. These cocoons are of pure

white, close-textured silk, and are quite conspicuous among raisins which have been infested with *Silvanus*. On 15th April the adult wasps emerged—about 31 days after oviposition.

From another egg, laid on or near 15th March, hatched a larva which was full-grown by the 18th, at the end of which day the remains of the beetle larva formed hardly more than a cap on its head and thorax. The next day, at 3 p.m., scarcely a sign of the host remained, and the parasite larva was lying on the bare glass, trying to spin a cocoon, but so far only achieving a thin carpet of diffuse silk. With continued efforts the carpet was merely somewhat thicker on the 21st. Evidently cocooning together makes the process easier. One egg per host was an abnormal event probably induced by frequent handling. This larva pupated, still naked on its carpet, sometime between 31st March and 1st April, and the adult emerged on the 14th, or about 30 days after oviposition.

*Behaviour of Adults.*—There are long and persistent cleaning operations, even the tip of the abdomen being doubled under and forward and cleaned by the mouth-parts.

The females seem to be sociable, often lying side by side for long periods without moving, or taking up a position in which they can titillate one another with the antennae. The vibration of the antennae is extremely fast, so that the organ looks double. I saw no reciprocal cleaning.

**Nemeritis canescens,** Grav.

This well-known parasite of various species of *Ephestia* was present in some numbers in Western Australia, in a packing-shed with a phenomenal infestation of *Ephestia cautella*, on which it was doubtless parasitic. It has already been recorded from Australia, for according to Morley (British Ichneumons, v, 1914, p. 134) it was described from flour mills in Victoria and New South Wales by Cameron, as a new species under the name of *Amorphota ephestiae*. Smits van Burgst (Tijdschr. Plantenziekten, Wageningen, xxvii, pp. 77–79) thinks it is monophagous; but this is not so, since besides the species of *Ephestia*, Richmond (J. Econ. Ent., xviii, p. 425) records it as parasitic on the wax-moth, *Galleria mellonella*, L., in Colorado.

# A NOTE ON THE UTILITY OF AERIAL PHOTOGRAPHY IN ENTOMOLOGICAL FIELD WORK.

By G. E. Bodkin, B. A., Dip. Agric. (Cantab.),
*Government Entomologist, Palestine.*

(Plates XVI–XVIII.)

In a previous paper (Bull. Ent. Res., xvi, 1925, p. 143), a general account was given of the conditions encountered in fumigation of citrus trees with hydrocyanic acid gas in Palestine.

In order to plan a campaign of fumigation against the locally termed "Black Scale" (*Chrysomphalus ficus*, Ashm.), a preliminary survey was made of the areas infested with this pest in Northern Palestine. Broadly speaking, the area in question was found to be divided up into two principal citrus producing districts; one situated in the vicinity of the village of Zeeb near the Northern Frontier, and the other, and larger area, to the South thereof comprising the villages of Kabri, Faraj, El-Naher and Himimeh.

At both these places the citrus cultivations follow the flow of spring water from the foothills down to the coast. Thus an ample and ready supply of water for irrigation is secured.

It soon became apparent, however, that the location of citrus gardens within any one of these areas was by no means an easy matter. The absence of maps or surveyors of any kind, the rough and tortuous nature of the paths and tracks which are utilised for transport, the high and almost impenetrable nature of the cactus hedges present in many gardens, which serve as wind screens as well as a means of security against theft and trespass, not to mention the somewhat inimical attitude of many of the cultivators themselves, all served to render the efficient prosecution of field fumigation work a far from easy matter.

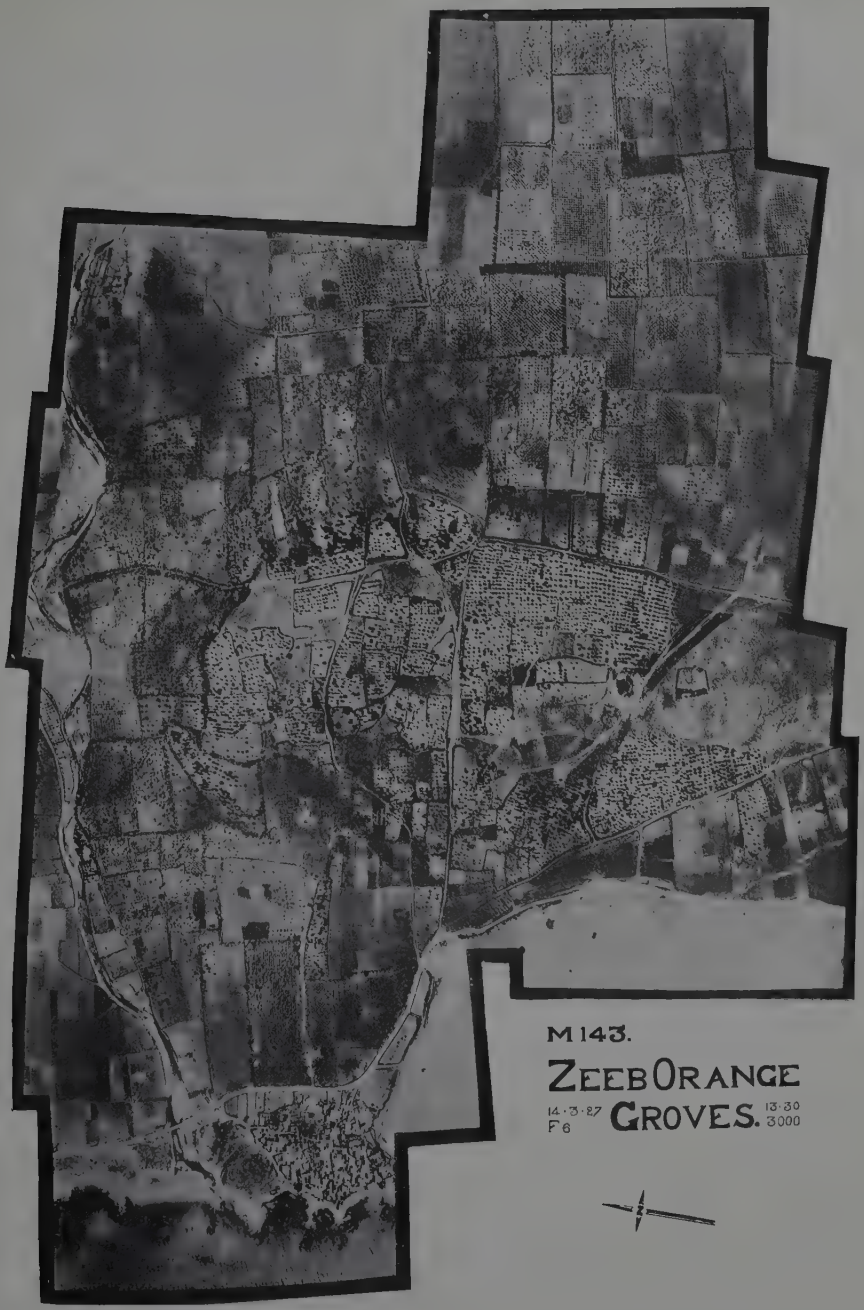
It was decided, therefore, to obtain an aerial photograph of these places and with the generous assistance of the Royal Air Force this was secured. Plate XVI is a reproduction of a very excellent air map of the cultivations, citrus and otherwise, near the village of Zeeb in the Acre-Sub-District of Northern Palestine.

Plate XVII is a reproduction of a tracing of the above-mentioned map, and it will be observed that every citrus cultivation has been marked with the owner's name, and notes as to fumigation work have been inserted.

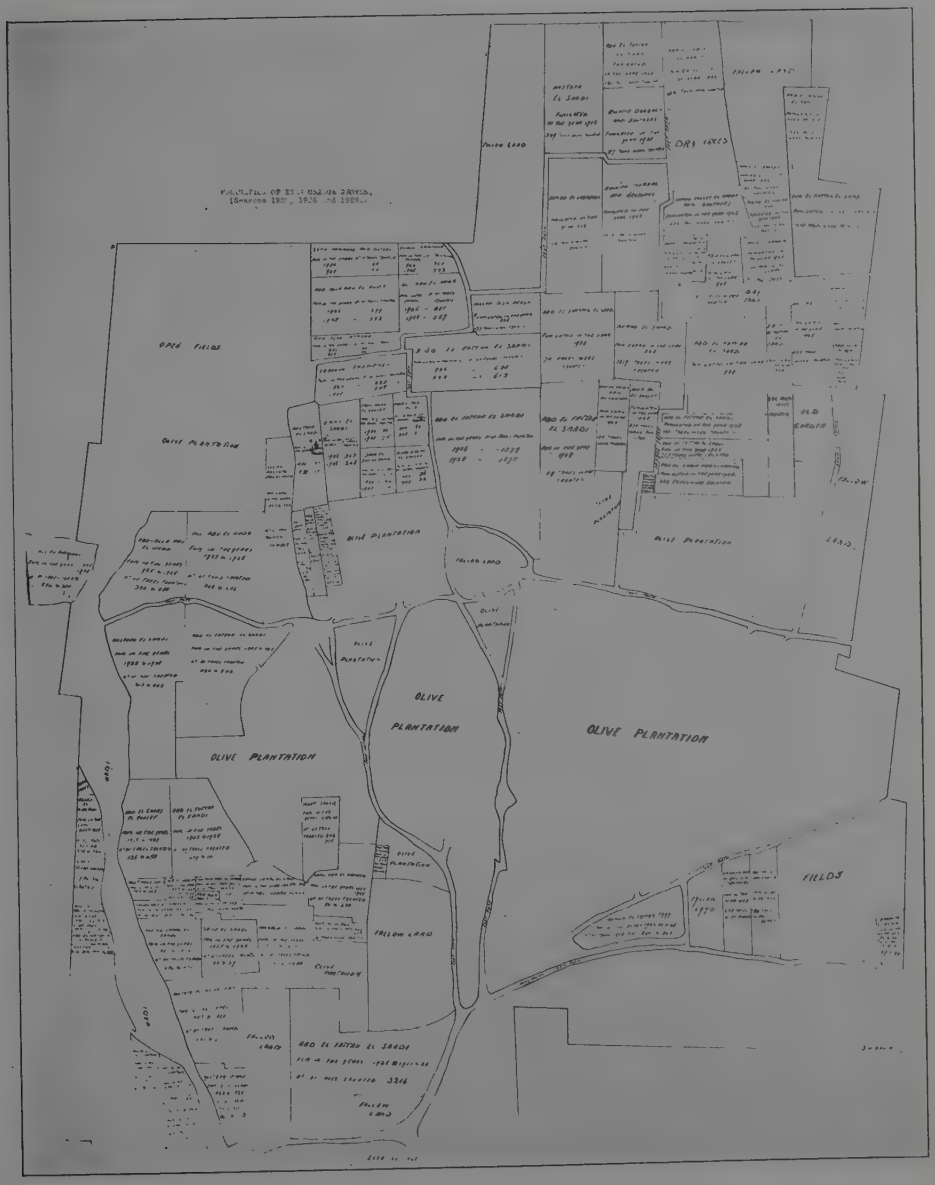
During 1928 every citrus plot in this area was fumigated, the total number of trees being 49,752. This work was performed by six fumigation outfits, and their operations were co-ordinated entirely by use of this map. There is no doubt that by adopting this method a very great saving in time and trouble was effected.

A photograph of the other previously mentioned and larger orange-growing area in this part of the country is reproduced in Plate XVIII, and it is being utilised during the fumigation season of 1929.

In conclusion my thanks and appreciation must be recorded to those members of the Royal Air Force who have taken so much pains in carrying out my requests, and to Mr. B. S. Farajallah and Mr. J. H. Brair who have conducted fumigation operations in the Northern District of Palestine.




Aerial photograph of cultivations near the village of Zeeb, Northern Palestine.




Prepared tracing of the aerial photograph of the cultivations near Zeeb village.

Another aerial photograph of citrus and other cultivation.

# GALL MIDGES (DIPT., CECIDOMYIDAE) AS ENEMIES OF APHIDS.

By H. F. Barnes, B.A., Ph. D.,

*Entomological Department, Rothamsted Experimental Station, Harpenden, England.*

## 1. Introduction.

The larvae of certain gall midges have been known for a long time to prey on Aphids; in fact Rondani in 1847 described a midge, now known as *Phaenobremia aphidimyza*, Rond., whose larvae fed on Aphids on fruit trees. Since this first record, there have been many notes of Aphids being attacked by Cecidomyid larvae, and in some cases the adult midge has been reared and described. Most of the literature consists of mere records of larvae feeding on Aphids or else descriptions of the midges; in a few cases biological notes are added. So far as the writer knows there are only two papers* that are devoted to a study of midges as a potential natural control of Aphids. Further work is badly needed to find out whether midge larvae can, or do, act as control agents.† There have been vague statements that Aphids in certain outbreaks have been controlled by the midge larvae, but so far there have been no exact proofs based on counts of numbers of Aphids killed, fecundity of midge compared with Aphid, the appetite of the midge larvae, etc.

It is a curious thing that in America the larvae of one species of midge, *Phaenobremia meridionalis*, Felt, are noted as feeding on various species of Aphids, while in Europe the Aphid-eating midges recorded seem to restrict themselves to one species of Aphid. Further work is necessary in the systematic field as well as in the economic.

It is with a view to stimulating such lines of research that this paper has been compiled. Each species of midge whose larvae have been reported as preying on Aphids is dealt with in order, and an alphabetical list of Aphids attacked by midge larvae is added. I am indebted to Mr. F. Laing, of the British Museum (Nat. Hist.), for his kind assistance with regard to Aphid nomenclature.

## 2. Gall Midge Species whose Larvae are known to attack Aphids.

### A. Internal Parasites.

*Endaphis perfidus*, Kieff.

Kieffer, Bull. Soc. ent. France, lxv, 1896, p. 383; Ann. Soc. ent. France, lxix, 1900, pp. 330–331.

Bagnall & Harrison, Trans. Ent. Soc. London, 1917, p. 390, 1918.

The female of this species lays its egg on the back of winged *Drepanosiphum platanoides*, Schr., on *Acer pseudoplatanus*. The larva lives inside the body of the Aphid and is visible by transparency owing to its bright red colour. At maturity the larva makes its way through the anus of the Aphid and " jumps " to the ground, where it pupates. There are several generations in the year. Keiffer records this species from Lorraine, and Bagnall & Harrison report it from Northumberland, England.

*Endaphis* sp.

Bagnall & Harrison, Trans. Ent. Soc. London, 1917, p. 390, 1918.

Bagnall & Harrison record the larva of a species of *Endaphis* as an internal parasite of an *Aphis* on *Ononis repens* in Durham, England.

---

*Davis, Jl. Agric. Res., vi, pp. 883–887, 1916.
Voukassovitch, C.R. Soc. Biol., xcii, pp. 357–359, 1925.

†In this connection Dr. W. R. Thompson has recently (*Bull. Ent. Res.*, xix, 1929, pp. 343–350) suggested that the value of predators in biological control has been underestimated, and that they are worthy of more careful attention in the field.

B. Predators.

*Trilobia aphisuga*, Del Guercio.

Del Guercio, Note ed Osservazioni di Entomologia Agraria, Not. Prelim., Bibl. Agr. Colon., 1918, pp. 223–226; L'Agric. Colon., Florence, xiii, 1919, pp. 46–49.

Del Guercio described this species from larvae found preying on Aphids on *Papaver* and *Vicia faba*.

*Uncinulella eriosomiperda*, Del Guercio.

Del Guercio, Note ed Osservazioni di Entomologia Agraria, Not. Prelim., Bibl. Agr. Colon., 1918, pp. 227–230; L'Agric. Colon., Florence, xiii, 1919, pp. 50–53.

This species was described from larvae found preying on Woolly Aphis (*Eriosoma lanigerum*), and it was claimed that as much as 15 per cent. of the Aphid was destroyed by these larvae.

*Isobremia sonchi* (Kieff.).

Kieffer, Bull. Soc. ent. France, lxv, 1896, p. 382 (*Bremia*); Ann. Soc. sci. Bruxelles, xxviii, 1904, p. 385 (*Aphidoletes*); Marcellia, xi, 1912, p. 231 (*Isobremia*); Genera Insectorum, fasc. 152, 1913, pp. 161–162.

Described from adults whose larvae fed on *Macrosiphum sonchi*, L., on *Sonchus oleraceus*. The larvae pupate in the soil.

*Isobremia kiefferi*, Voukassovitch.

Voukassovitch, C.R. Soc. Biol., xcii, 1925, pp. 357–359.

This species is reported in France feeding on *Macrosiphum rosae*, L., *Capitophorus rosarum*, Kalt., and *Anuraphis kochi*, Schout., as well as on other unidentified Aphids. Under artificial conditions the larvae are full-grown in 4 days at 20° C. (68° F.); the prepupal stage lasts 10 days and the pupal stage 7 days at 24° C. (75·2° F.). There are several generations a year, and the larvae are parasitised by the Proctotrupid, *Synopeas rhanis*, Wlk.

*Cryptobremia aegyptiaca*, Kieff.

Kieffer, Neue Gallmücken Gattung, Bitsch, 1912, p. 1; Genera Insectorum, fasc. 152, 1913, p. 160.

Described from adults the larvae of which fed on *Aphis gossypii*, Glov., in Egypt.

*Aphidoletes abietis* (Kieff.).

Kieffer, Bull. Soc. ent. France, lxv, 1896, p. 382 (*Bremia*); Ann. Soc. sci. Bruxelles, xxviii, 1904, p. 385 (*Aphidoletes*); Genera Insectorum, fasc. 152, 1913, pp. 163–164.

Bagnall & Harrison, Trans. Ent. Soc. London, 1917, p. 389, 1918.

Described from adults from larvae preying on *Adelges abietis* in Lorraine. Metamorphosis in the ground. Bagnall & Harrison recorded it from Durham, England.

*Aphidoletes* sp.

Felt, Jl. N.Y. Ent. Soc., xx, 1912, p. 245.

Larvae were found on apple leaves infested with *Anuraphis roseus*, Baker (*malifoliae*, Fitch) at Nassau, N.Y.

*Aphidoletes* sp.

Davis & Satterthwait, Purdue Univ. Agric. Sta. Bull., no. 185, 1916.

Larvae recorded as preying on *Aphis pseudobrassicae* on False Cabbage in Indiana, U.S.A.

*Aphidoletes* sp.

Davis, U.S. Dept. Agric., Ent. Tech. Ser., Bull. no. 25, pt. ii, 1914.

Larvae reported as feeding on *Callipterus trifolii*, Monl. (a synonym of *Therioaphis ononidis*, Kalt.) in captivity at La Fayette, Indiana, U.S.A.

*Aphidoletes* sp.

Vassiliev, [Mem. Bur. Ent. Sci. Com. Central Bd. Land. Adm. & Agric., St. Petersburg], x, 1914.

Larvae reported as an enemy of *Aphis gossypii*, Glov., on cotton in Fergana, Russia.

*Aphidoletes* sp.

Vassiliev, [Cotton Indust.] iii, 1914.

Larvae reported feeding on *Aphis gossypii*, Glov., on cotton in Turkestan.

*Aphidoletes* sp.

Webster, Iowa St. Coll. Agric. Expt. Sta., Bull. no. 173, 1917.

Larvae reported feeding on *Chaitophorus negundinis*, Thos., the box elder Aphid.

*Bremia* sp.

Dobrovliansky, [Kiev Ent. Sta. S. Russia Agric. Syn.], Kiev, 1913.

Larvae reported attacking *Aphis pomi*, DeG., round Kiev in 1912.

*Bremia* sp.

Dobrovliansky, *l.c.*

Larvae reported attacking *Myzus cerasi*, F., round Kiev in 1912.

*Bremia* sp.

Dobrovliansky, *l.c.*

Larvae reported attacking *Capitophorus ribis*, L., round Kiev in 1912.*

*Phaenobremia aphidimyza* (Rond.).

Rondani, Nuovi Ann. Sc. Nat. Bologna, (2) viii, 1847, p 443 (*Cecidomyia*) ; Atti Soc. Ital. Sc. Nat. Milano, ii, 1860, p. 289 (*Bremia*).

Loew, D. B., iv, 1850, p. 34 (*Cecidomyia cerasi*).

Bergenstamm & Loew, Verh. z.-b. Ges. Wien, xxvi, 1876, p. 27 (*Diplosis*).

Rübsaamen, Berlin. ent. Zeit., xxxvii, 1892, p. 390 (*Diplosis*).

Kieffer, Bull. Soc. Hist. nat. Metz, (2) viii, 1898, p. 27 (*Bremia*) ; Ann. Soc. ent. France, lxix, 1900, pp. 331–332 (*Bremia*) ; Ann. Soc. sci. Bruxelles, xxviii, 1904, p. 385 (*Aphidoletes*) ; Genera Insectorum, fasc. 152, 1913, p. 161 (*Phaenobremia*).

The exact identity of this species is uncertain, as without doubt several species have been recorded under this name. Kieffer and Rübsaamen considered *Cecidomyia cerasi*, H.Lw., to be a synonym. Bergenstamm & Loew recorded it as feeding on Aphids on *Persica*, *Cerasus*, *Sonchus* and *Rosa*, and Kieffer states that it was found on peach, plum, rose and sow-thistle. Rondani recorded it from Italy, and Kieffer (1898) reported it from Germany, Austria and France.

* Since going to press, a *Phaenobremia* sp. has been reared from larvae feeding on this Aphid at Harpenden, England, during July and August, 1929.

*Phaenobremia aphidisuga* (Rübs.).

Rübsaamen, Wien. ent. Zeit., x, 1891, p. 8 (*Diplosis*).

Kieffer, Bull. Soc. Hist. nat. Metz, (2) viii, 1898, p. 27 (*Bremia*); Ann. Soc. sci. Bruxelles, xxviii, 1904, p. 385 (*Aphidoletes*); Genera Insectorum, fasc. 152, 1913, p. 161 (*Phaenobremia*).

This species is reported from Germany and France as feeding on Aphids on *Cirsium arvense.*

*Phaenobremia aphidivora* (Rübs.).

Rübsaamen, Wien. ent. Zeit., x, 1891, p. 14 (*Diplosis*).

Kieffer, Bull. Soc. Hist. nat. Metz, (2) viii, 1898, p. 27 (*Bremia*); Ann. Soc. sci. Bruxelles, xxviii, 1904, p. 385 (*Aphidoletes*); Genera Insectorum, fasc. 152, 1913, p. 161 (*Phaenobremia*).

Reported as feeding on Aphids on *Heracleum sphondylium* in Germany.

*Phaenobremia basalis* (Felt).

Felt, N.Y. St. Mus., Bull. no. 124, 1908, p. 397 (*Aphidoletes*); N.Y. St. Mus., Bull. no. 202, 1918, pp. 140–141 (*Aphidoletes*).

Kieffer, Genera Insectorum, fasc. 152, 1913, p. 161 (*Phaenobremia*).

Reared from *Tanacetum vulgare*, probably infested with Aphids, at Albany, N.Y.

*Phaenobremia borealis* (Felt).

Felt, N.Y. St. Mus., Bull. no. 124, 1908, p. 397 (*Aphidoletes*); N.Y. St. Mus., Bull. no. 202, 1918, pp. 139–140 (*Aphidoletes*).

Kieffer, Genera Insectorum, fasc. 152, 1913, p. 161 (*Phaenobremia*).

Reared at Albany, N.Y., from tulip leaves presumably infested with Aphids.

*Phaenobremia cardui*, Kieff.

Kieffer, Bull. Soc. Hist. nat. Metz, xxviii, 1913, p. 50.

Recorded as feeding on *Anuraphis cardui*, L., at Bitsch, Lorraine, male, pupa and larva being described. The larva pupates in the soil.

*Phaenobremia carnifex* (Kieff.).

Kieffer, Rev. Russe d'Ent. 1907, p. 200, 1908 (*Aphidoletes*); Genera Insectorum, fasc. 152, 1913, p. 161 (*Phaenobremia*).

Sacharov, Publ. Ent. St. Astrachan, 1915 (*Aphidoletes*).

Adults described from larvae preying on *Aphis gossypii*, Glov., on *Cucumis sativa* in Astrakhan.

*Phaenobremia cucumeris* (Lintn.).

Lintner, Rept. 11 Inj. Ins. N.Y. St. 1895, p. 165, 1896 (*Diplosis*).

Felt, Psyche, viii, 1895, pp. 4–5 (*Cecidomyia*); N.Y. St. Mus., Bull. no. 124, 1908, p. 397 (*Aphidoletes*); N.Y. St. Mus., Bull. no. 202, 1918, pp. 138–139 (*Aphidoletes*).

Kieffer, Ann. Soc. sci. Bruxelles, xxviii, 1904, p. 385 (*Aphidoletes*); Genera Insectorum, fasc. 152, 1913, p. 161 (*Phaenobremia*).

This species was reared from larvae preying on *Aphis gossypii*, Glov., in U.S.A.

*Phaenobremia fulva* (Felt).

Felt, N.Y. St. Mus., Bull. no. 124, 1908, p. 397 (*Aphidoletes*); N.Y. St. Mus., Bull. no. 202, 1918, p. 136 (*Aphidoletes*).

Kieffer, Genera Insectorum, fasc. 152, 1913, p. 161 (*Phaenobremia*).

Ross & Caesar, 50th Ann. Rept. Ent. Soc. Ontario, 1919, p. 101, 1920 (*Aphidoletes*).

A captured male was described by Felt. Reported as attacking *Brevicoryne brassicae*, L., in Ontario by Ross & Caesar.

*Phaenobremia helichrysis*, Barnes.

Barnes, Entomologist, lx, 1927, pp. 176–177.

Described from adults reared from larvae found feeding in Co. Dublin, Ireland, on *Anuraphis padi*, L., on yarrow. Larvae have also been found on a yarrow Aphid (probably *A. padi*, L.) on Boar's Hill, near Oxford, England.

*Phaenobremia impatientis* (Kieff.).

Kieffer, Bull. Soc. Hist. nat. Metz, xxi, 1901, p. 169 (*Bremia*); Genera Insectorum, fasc. 152, 1913, p. 161 (*Phaenobremia*).

Adults described from larvae feeding on *Macrosiphoniella balsamines*, Kalt., on *Impatiens noli-me-tangere* in the forests of Bitsch, Lorraine.

*Phaenobremia kiefferiana*, Tolg.

Tolg, Verh. z.-b. Ges. Wien, lxiii, 1913; Neue Beitr. system. Insektenbiol, ii, 1922, p. 33.

This species is described as feeding on Aphids in Austria.

*Phaenobremia macrorosae*, Barnes.

Barnes, Entomologist, lx, 1927, pp. 177–178.

Described from females reared from larvae attacking *Macrosiphum rosae*, L., var. *glauca*, Buckt., found at St. Andrews, Scotland, by Miss Jackson who stated that the larvae were sometimes very numerous.

*Phaenobremia marina* (Felt).

Felt, N.Y. St. Mus., Bull. no. 124, 1908, p. 397 (*Aphidoletes*); Jl. Econ. Ent., vii, 1914, p. 458 (*Aphidoletes*); N. Y. St. Mus., Bull. no. 202, 1918, p. 140 (*Aphidoletes*).

Kieffer, Genera Insectorum, fasc. 152, 1913, p. 161 (*Phaenobremia*).

Described from a captured male, but later listed as preying on *Aphis gossypii*, Glov., by Felt (1914) in U.S.A.

*Phaenobremia meridionalis* (Felt).

Felt, N.Y. St. Mus., Bull. no. 124, 1908, p. 397 (*Aphidoletes*); N.Y. St. Mus., Bull. no. 202, 1918, pp. 137–138 (*Aphidoletes*).

Webster & Phillips, U.S. Dept. Agric., Bur. Ent., Bull. no. 110, 1912, p. 133 (*Aphidoletes*).

Davis, Jl. Agr. Res., vi, 1916, pp. 883–887 (*Aphidoletes*).

Ross, Rept. Ent. Soc. Ontario, xlvii, 1917, p. 26 (*Aphidoletes*); *op. cit.*, xlviii, 1918 (*Aphidoletes*).

Kieffer, Genera Insectorum, fasc. 152, 1913, p. 161 (*Phaenobremia*).

Barnes, Entomologist, lx, 1927, p. 175 (*Phaenobremia*).

This is the one of the two species that have been studied in any detail. Davis (1916) came to the conclusion that in certain cases it acts as a control of Aphids, *e.g.*, in an attack of *Aphis gossypii* on *Nepeta cataria*, L. He reported it as a general Aphid-feeder in America and records the following Aphids as attacked:—*Aphis nerii*, Boy. (*asclepiadis*, Fitch), *Aphis avenae*, F., *Anuraphis cardui*, L., *A. gossypii*, Glov., *A. helianthi*, Monl., *A. maidis*, Fitch, *Hystoneura setariae*, Thos., *Chaitophorus*

*negundinis*, Thos., *Hyalopterus arundinis*, F., *Macrosiphum granarium*, Kirby, *Illinoia pisi*, Kalt., *Macrosiphum sonchella*, Monl., *Myzus persicae*, Sulz., *Phorodon humuli*, Schr., *Rhopalosiphum sonchi*, Oestl., *Sipha flava*, Forbes, *Cavariella pastinaceae*, L., and *Toxoptera graminum*, Rond. Ross (1917) recorded it attacking *Aphis pomi*, DeG., and the same author (1918) recorded it attacking *Myzus cerasi*, F., both records from Canada. Felt (1918) recorded it from *Macrosiphum liriodendri*, Monl. Barnes (1927) recorded it as feeding on *Phorodon humuli*, Schr., in Kent, England, while Mr. H. Britten found *Phaenobremia* larvae, probably this species, feeding on the same Aphid at Marple, Cheshire, 1 viii 26. Recently Dr. F. X. Williams has submitted for identification specimens reared from larvae found preying on the sugar-cane Aphid (*A. sacchari*) by H. T. Osborn in Oahu and Hawaii in the Hawaiian Islands in 1919. After comparison with specimens of *P. meridionalis*, Felt (Cecid. 1373–4 in the writer's collection), labelled ' La Fayette, Indiana, 1915,' presumably some of the specimens sent by Dr. J. J. Davis to Dr. Felt for identification, and a homotype (Cecid. 398) reared from a larva found in Kent, these Hawaiian specimens (Cecid. 1369–72) have been provisionally assigned to this species, as they are morphologically indistinguishable from *P. meridionalis*, Felt.*

The whole life-cycle takes 15–29 days, and there may be as many as 6 generations in the year in Indiana, U.S.A. Mating and egg-laying occur in captivity at night. The larva usually sucks the Aphid from one of the articulations of the legs, a favourite point of attack being the articulation of the tibia and femur. Webster & Phillips state that the larva can suck a small Aphid dry in a few minutes, and a full-grown Aphid is deflated in 15–30 minutes. The observation that Aphids are not always sucked dry but only till they are dead tends to show that a larva can account for more larvae than would otherwise be the case. The adult midges live up to 14 days, and egg-laying goes on for 10 days.

*Phaenobremia rosea*, Barnes.

Barnes, Entomologist, lx, 1927, pp. 175–176.

Described from females reared from larvae found in Kent, England, feeding on *Anuraphis roseus*, Baker. Adult midges developing from a single batch of larvae feeding in August may emerge either in September or in the following May and June. Males (Cecid. 1296, 1297, 1300) have since been reared in 1929.

*Phaenobremia rosivora* (Coq.).

Coquillet, U.S. Dept. Agric., Div. Ent., Bull. no. 22, 1900, pp. 46–77 (*Diplosis*).

Felt, Jl. Econ. Ent., iv, 1911, p. 468 (*Clinodiplosis*) ; N.Y. St. Mus., Bull. no. 202, 1918, p. 137 (*Aphidoletes*).

Barnes, Entomologist, lx, 1927, pp. 179–180 (*Phaenobremia*).

This species was bred from larvae in U.S.A. associated with *Dasyneura rhodophaga*, Coq., but was evidently preying on rose Aphids.

*Phaenobremia urticariae* (Kieff.).

Kieffer, Feuilles Jeunes Nat., Paris, xxvi, 1895, p. 9 (*Bremia*) ; Ann. Soc. sci. Bruxelles, xxviii, 1904, p. 385 (*Aphidoletes*) ; Genera Insectorum, fasc. 152, 1913, p. 161 (*Phaenobremia*).

This species is reported as preying on *Aphis urticaria*, Kalt., in Lorraine.

* The writer believes that physiological differences may be of the same value in separating species as morphological differences. He hopes to find out whether the progeny of one *Phaenobremia* female will (*a*) feed on different species of Aphids in starvation tests, (*b*) will show a host preference to different Aphid species, (*c*) will feed on the same Aphid species on any of the latter's host-plants, *e.g.*, on *Phorodon humuli* living on hop and damson, and also whether isolation of any kind tends to prevent individuals feeding on different species of Aphids from inter-breeding.

*Phaenobremia vacunae*, Kieff.

Kieffer, Bull. Soc. Hist. nat. Metz, xxviii, 1913, p. 51.

This species is described on larvae found preying on *Thelaxes dryophila*, Schr., at Bitsch, Lorraine.

*Phaenobremia* sp.

The writer has in his collection larvae belonging to this genus found feeding on the following Aphids—*Aphis pomi*, DeG. (England), *Macrosiphum schranki*, Theob. (Wales), *M. jaceae*, L. (England), *Macrosiphum* sp. on *Urtica* (Wales), *Hyalopterus trirhoda*, Wlk. (England), *Hyalopterus arundinis*, F. (England), *Myzus cerasi*, F. (England), *Macrosiphoniella* sp. on *Tanacetum vulgare* (Wales) and on *M. absinthii*, L. (England).

Bagnall & Harrison (Trans. Ent. Soc. London, 1917, p. 389, 1918) also record larvae of *Phaenobremia* sp. feeding on *Aphis pomi* in Durham, England.

*Guerciobremia bezzii* (Del Guercio).

Del Guercio, Bibl. Agr. Colon., 1918, pp. 187–202 (*Rondaniella*).

Barnes, Ent. Mo. Mag., lxiii, 1927, p. 221 (*Guerciobremia*).

Described from midges reared from larvae preying on *Aphis symphyti*, Schr.

*Guerciobremia cucullata* (Del Guercio).

Del Guercio, Bibl. Agr. Colon., 1918, pp. 218–222 (*Rondaniella*) ; L'Agric. Colon., Florence, xiii, 1919, pp. 41–45 (*Rondaniella*).

Described from larvae found preying on *Toxoptera* on *Ligustrum vulgare*. It was stated that these larvae together with *Aphidius* sometimes reduce the numbers of the Aphid so that no damage results.

*Guerciobremia macrosiphoniellae* (Del Guercio).

Del Guercio, Bibl. Agr. Colon., 1918, pp. 213–214 (*Rondaniella*) ; L'Agric. Colon., Florence, xiii, 1919, pp. 36–37 (*Rondaniella*).

Described from larvae found preying on *Macrosiphoniella* sp. on chrysanthemum.

*Guerciobremia macrosiphonis* (Del Guercio).

Del Guercio, Bibl. Agr. Colon., 1918, pp. 210–212 (*Rondaniella*) : L'Agric. Colon., Florence, xiii, 1919, pp. 33–35 (*Rondaniella*).

Described from larvae found feeding on *Macrosiphum* on artichoke.

*Guerciobremia ornata* (Del Guercio).

Del Guercio, Bibl. Agr. Colon., 1918, pp. 215–217 (*Rondaniella*) ; L'Agric. Colon., Florence, xiii, 1919, pp. 38–40 (*Rondaniella*).

Described from larvae preying on Aphids on quince.

*Guerciobremia phorodontis* (Del Guercio).

Del Guercio, Bibl. Agr. Colon., 1918, pp. 208–209 (*Rondaniella*) ; L'Agric. Colon., Florence, xiii, 1919, pp. 31–32 (*Rondaniella*).

Described from larvae preying on *Phorodon humuli*, Schr., on hops.

*Guerciobremia toxopterae* (Del Guercio).

Del Guercio, Bibl. Agr. Colon., 1918, pp. 203–207 (*Rondaniella*).

Described from larvae feeding on *Toxoptera aurantii*, Boyer, on *Citrus limonum*.

*Monobremia subterranea* (Kieff.).

Kieffer, Bull. Soc. Hist. nat. Metz, viii, 1898, p. 27 (*Bremia*); Ann. Soc. sci. Bruxelles, xxviii, 1904, p. 385 (*Aphidoletes*); Neue Gallmücken Gattung, Bitsch, 1912, p. 1 (*Monobremia*); Bull. Soc. Hist. nat. Metz, xxviii, 1913, p. 51.

This species lives in the larval stage on an *Aphis* on roots of *Tanacetum vulgare* in Lorraine. The male and larva were described.

*Adelgimyza strobilobii*, Del Guercio.

Del Guercio, Bibl. Agric. Colon., 1918, pp. 231–236; L'Agric. Colon., Florence, xiii, 1919, pp. 54–59.

Described from adults whose larvae prey on *Adelges strobilobius*, Kalt., on larch.

*Lestodiplosis grassator* (Fyles).

Fyles, Canad. Ent., xiv, 1882, pp. 237–239 (*Diplosis*).

Felt, N.Y. St. Mus., Bull. no. 124, 1908, p. 408 (*Lestodiplosis*); *op. cit.*, no. 231–232, 1921, pp. 138–139 (*Lestodiplosis*).

This species was reared in Ontario from larvae feeding on *Phylloxera vastatrix*, Pl. The eggs are laid at or near the entrance to the galls, and one or two larvae may be found in a gall.

*Lestodiplosis pini*, Barnes.

Barnes, Ent. Mo. Mag., lxiv, 1927, pp. 73-74.

Described from midges reared from larvae found in Cheshire, England, on *Pinus strobus* and said to be feeding on Aphids.

*Cecidomyia aphidivora* (Felt).

Felt, Jl. N.Y. Ent. Soc., xx, 1912, pp. 245–246 (*Itonida*); N.Y. St. Mus., Bull. no. 231–232, 1921, p. 188 (*Itonida*).

This species was reared from larvae found together with those of an *Aphidoletes* sp. on apple leaves infested with *Anuraphis roseus*, Baker (*malifoliae*, Fitch) at Nassau, N.Y. It was not definitely stated whether these larvae were eating the Aphids or not.

*Undetermined species.*

Bagnall & Harrison (Ent. Rec., xxxiv, 1922, p. 62) record larvae feeding on an Aphid on *Salix cinerea*, and also (*t.c.*, p. 153) larvae on an Aphid on bramble, both from England.

### 3. Gall Midge Species whose Larvae presumably feed on Aphids.

Several species of *Phaenobremia* have been described from captured adults and nothing is known concerning their biology. Three species from the United States of America were described by Felt (N.Y. St. Mus., Bull. no. 202, 1918) under the genus *Aphidoletes*, viz. *flavida* (pp. 138–139), *marginata* (pp. 135–136) and *recurvata* (pp. 136–137); eight species were described by Skuse (Proc. Linn. Soc. N.S. Wales, (2) iii, 1888) under the genus *Diplosis*, viz. *actiosa* (pp. 105–106), *cineraria* (p. 106), *contigua* (pp. 103–104), *fallax* (pp. 85–86), *indotata* (p. 107), *oreas* (pp. 107–108), *saxatilis* (pp. 102–103), and *violacea* (pp. 101–102).

### 4. List of Aphids known to be attacked by Gall Midge Larvae.

A. Identified Aphids.

| Aphid. | Midge. | Country. |
|---|---|---|
| *abietis*, L. (*Adelges*) | *Aphidoletes abietis* (Kieff.) | Lorraine, England. |
| *absinthii*, L. (*Macrosiphoniella*) | *Phaenobremia* sp. | England. |
| *arundinis*, F. (*Hyalopterus*) | *Phaenobremia* sp. | England. |
| | *Phaenobremia meridionalis* (Felt) | |

| Aphid. | Midge. | Country. |
|---|---|---|
| *asclepiadis*, Fitch (*Aphis*) (see *nerii*, Boyer) | | |
| *aurantii*, Boyer (*Toxoptera*) | *Guerciobremia toxopterae* (Del Guercio) | Italy.* |
| *avenae*, F. (*Aphis*) | *Phaenobremia meridionalis* (Felt) | U.S.A. |
| *balsamines*, Kalt. (*Macrosiphoniella*) | *Phaenobremia impatientis* (Kieff.) | Lorraine. |
| *brassicae*, L. (*Brevicoryne*) | *Phaenobremia fulva* (Felt) | Canada. |
| *cardui*, L. (*Anuraphis*) | *Phaenobremia cardui*, Kieff. | Lorraine. |
| | *Phaenobremia meridionalis* (Felt) | U.S.A. |
| *cerasi*, F. (*Myzus*) | *Bremia* sp. | Russia. |
| | *Phaenobremia meridionalis* (Felt) | Canada. |
| | *Phaenobremia* sp. | England. |
| *dryophila*, Schr. (*Thelaxes*) | *Phaenobremia vacunae*, Kieff. | Lorraine. |
| *flava*, Forbes (*Sipha*) | *Phaenobremia meridionalis* (Felt) | U.S.A. |
| *gossypii*, Glov. (*Aphis*) | *Cryptobremia aegyptiaca*, Kieff. | Egypt. |
| | *Aphidoletes* sp. | Russia. |
| | *Phaenobremia carnifex* (Kieff.) | Astrakhan. |
| | *Phaenobremia cucumeris* (Lintn.) | U.S.A. |
| | *Phaenobremia meridionalis* (Felt) | U.S.A. |
| | *Phaenobremia marina* (Felt) | U.S.A. |
| *graminum*, Rond. (*Toxoptera*) | *Phaenobremia meridionalis* (Felt) | U.S.A. |
| *granarium*, Kirby (*Macrosiphum*) | *Phaenobremia meridionalis* (Felt) | U.S.A. |
| *helianthi*, Monl. (*Aphis*) | *Phaenobremia meridionalis* (Felt) | U.S.A. |
| *humuli*, Schrk. (*Phorodon*) | *Phaenobremia meridionalis* (Felt) | U.S.A., England. |
| | *Guerciobremia phorodontis* (Del Guercio) | Italy.* |
| *jaceae*, L. (*Macrosiphum*) | *Phaenobremia* sp. | England. |
| *kochii*, Schout. (*Anuraphis*) | *Isobremia kiefferi*, Vouk. | France. |
| *lanigerum*, Hausm. (*Eriosoma*) | *Uncinulella eriosomiperda*, Del Guercio | Italy.* |
| *liriodendri*, Monl. (*Macrosiphum*) | *Phaenobremia meridionalis* (Felt) | U.S.A. |
| *maidis*, Fitch (*Aphis*) | *Phaenobremia meridionalis* (Felt) | U.S.A. |
| *malifoliae*, Fitch (*Aphis*) (see *roseus*, Baker) | | |
| *negundinis*, Thos. (*Chaitophorus*) | *Aphidoletes* sp. | U.S.A. |
| | *Phaenobremia meridionalis* (Felt) | U.S.A. |
| *nerii*, Boyer (*Aphis*) | *Phaenobremia meridionalis* (Felt) | U.S.A. |
| *ononidis*, Kalt. (*Therioaphis*) | *Aphidoletes* sp. | U.S.A. |
| *padi*, L. (*Anuraphis*) | *Phaenobremia helichrysis*, Barnes | Ireland, England. |
| *pastinaceae*, L. (*Cavariella*) | *Phaenobremia meridionalis* (Felt) | U.S.A. |
| *persicae*, Sulz. (*Myzus*) | *Phaenobremia meridionalis* (Felt) | U.S.A. |
| *pisi*, Kalt. (*Illinoia*) | *Phaenobremia meridionalis* (Felt) | U.S.A. |
| *platanoides*, Schr. (*Drepanosiphum*) | *Endaphis perfidus*, Kieff. | Lorraine, England. |
| *pomi*, DeG. (*Aphis*) | *Bremia* sp. | Russia. |
| | *Phaenobremia meridionalis* (Felt) | Canada. |
| | *Phaenobremia* sp. | England. |
| *pruni*, F. (*Hyalopterus*) (see *arundinis*, F.). | | |

* Presumably all Del Guercio's species were found in Italy although this is not actually stated in his works.

| Aphid. | Midge. | Country. |
|---|---|---|
| *pseudobrassicae*, Davis (*Aphis*) | *Aphidoletes* sp. | U.S.A. |
| *ribis*, L. (*Capitophorus*) | *Bremia* sp. | Russia. |
| | *Phaenobremia* sp. | England. |
| *rosae*, L. (*Macrosiphum*) | *Isobremia kiefferi*, Vouk. | France. |
| *rosae*, L., var. *glauca*, Buckt. (*Macrosiphum*) | *Phaenobremia macrorosae*, Barnes | Scotland. |
| *rosarum*, Kalt. (*Capitophorus*) | *Isobremia kiefferi*, Vouk. | France. |
| *roseus*, Baker (*Anuraphis*) | *Phaenobremia rosea*, Barnes | England. |
| | *Cecidomyia aphidivora* (Felt) | U.S.A. |
| | *Aphidoletes* sp. | U.S.A. |
| *sacchari*, Zehnt. (*Aphis*) | *Phaenobremia meridionalis* (Felt) | Hawaiian Islands. |
| *schranki*, Theob. (*Macrosiphum*) | *Phaenobremia* sp. | Wales. |
| *setariae*, Thos. (*Hystoneura*) | *Phaenobremia meridionalis* (Felt) | U.S.A. |
| *sonchella*, Monl. (*Macrosiphum*) | *Phaenobremia meridionalis* (Felt) | U.S.A. |
| *sonchi*, Oestl. (*Rhopalosiphum*) | *Phaenobremia meridionalis* (Felt) | U.S.A. |
| *sonchi*, L. (*Macrosiphum*) | *Isobremia sonchi* (Kieff.) | Lorraine. |
| *strobilobius*, Kalt. (*Adelges*) | *Adelgimyza strobilobii*, Del Guercio | Italy.* |
| | *Aphidoletes* sp. | England. |
| *symphyti*, Schr. (*Aphis*) | *Guerciobremia bezzii* (Del Guercio) | Italy.* |
| *trifolii*, Monl. (see *ononidis*, Kalt.) | | |
| *trirhoda*, Walk. (*Hyalopterus*) | *Phaenobremia* sp. | England. |
| *urticaria*, Kalt. (*Aphis*) | *Phaenobremia urticariae* (Kieff.) | Lorraine. |
| *vastatrix*, Pl. (*Phylloxera*) | *Lestodiplosis grassator* (Fyles) | N. America. |

B. Unidentified Aphids.

| Plant. | Midge. | Country. |
|---|---|---|
| Artichoke | *Guerciobremia macrosiphonis* (Del Guercio) | Italy.* |
| *Chrysanthemum* | *Guerciobremia macrosiphoniellae* (Del Guercio) | Italy.* |
| *Cirsium arvense* | *Phaenobremia aphidisuga*, Rübs. | Germany, France. |
| *Cydonia vulgaris* | *Guerciobremia ornata* (Del Guercio) | Italy.* |
| *Heracleum sphondylium* | *Phaenobremia aphidivora* (Rübs.) | Germany. |
| *Ligustrum vulgare* | *Guerciobremia cucullata* (Del Guercio) | Italy.* |
| *Ononis repens* | *Endaphis* sp. | England. |
| *Pinus strobus* | *Lestodiplosis pini*, Barnes | England. |
| *Rosa* | *Phaenobremia rosivora* (Coq.) | U.S.A. |
| *Rubus* | *Cecid.* sp. | England. |
| *Papaver* | *Trilobia aphidisuga*, Del Guercio | Italy.* |
| *Salix cinerea* | *Cecid.* sp. | England. |
| *Tulipa* | *Phaenobremia borealis* (Felt) | U.S.A. |
| *Tanacetum vulgare* | *Phaenobremia basalis* (Felt) | U.S.A. |
| | *Phaenobremia* sp. | Wales. |
| Roots of *T. vulgare* | *Monobremia subterranea* (Kieff.) | Lorraine. |
| *Urtica* | *Phaenobremia* sp. | Wales. |
| *Vicia faba* | *Trilobia aphidisuga*, Del Guercio | Italy.* |

*Phaenobremia aphidimyza* (Rond.) reported from Aphids on *Persica*, *Cerasus*, *Sonchus*, *Rosa*, Peach, Plum and Sow-thistle, is not included in the list as the species is so doubtful.

* Presumably all Del Guercio's species were found in Italy although this is not actually stated in his works.

# SEVEN NEW SPECIES OF BRACONIDAE. W.

By D. S. Wilkinson,
*Senior Assistant, Imperial Bureau of Entomology.*

**Apanteles pistrinariae,** sp. n.

♀. Black ; scape, mouthparts (or at least palpi), tegulae, costal veins, legs and abdomen entirely (except as follows), red testaceous ; hind tarsi, extreme apex of hind tibiae, extreme base of hind coxae, occasionally very slightly darkened ; 1st and 2nd tergites, and ovipositor sheaths, black ; 3rd tergite dark red, at least darker than ventrites and apical tergites ; flagellum brown ; stigma, metacarp, and most other veins, brown or light reddish brown.

♂. The single male agrees in colour with the females except that all the tergites are darkened.

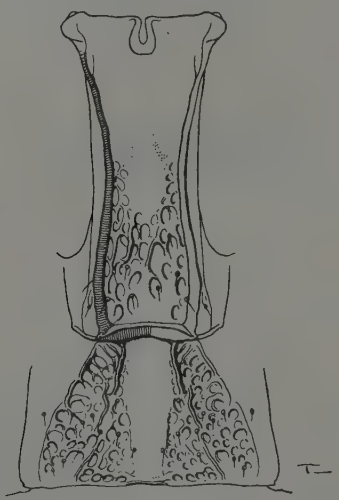


Fig. 1. *Apanteles pistrinariae,* sp. n.: 1st and 2nd tergites.

♀♂. *Head* : face minutely punctate ; toruli nearer to apex of clypeus than to eyes ; posterior ocelli rather nearer to each other than to eyes ; frons, vertex, and occiput, smooth and shining, with only extremely minute and sparse punctation. *Thorax* : mesonotum punctate (degree 2–3), the punctures rather shallow and tending possibly to coalesce thus giving a weakly rugose appearance, particularly along the lines of the notauli ; disc of scutellum shining, with some minute punctures, more punctate (or indefinitely sculptured) along the sides ; propodeon with weakly marked, but definitely present, transverse basal carinae, anterior to which the propodeon is shining and largely smooth, and posterior to which it is rugulose ; propodeon medianly with a slight longitudinal excavation, particularly in basal half, in which an extremely weak carina is sometimes discernible. *Wings* : the breadth of the stigma equal to or rather greater than the length of the transverse cubital, which latter is longer than (very rarely equal to), and normally angled with, the 1st abscissa of the radial, and without indication of even pigmentation of a stump of a 2nd radial abscissa ; recurrent equal to the 1st abscissa of the radial, longer than the apical portion of the 1st abscissa

of the cubital, this latter normally rather longer than the pigmented portion of the 2nd abscissa of the cubital which is equal to the upper portion of the basal vein; the three last-mentioned veins variable, often equalling each other in length; stigma shorter than metacarp. *Legs*: hind coxae in upper half shining and virtually smooth, save for some minute punctation and for some occasional, larger, indefinite punctures; the longer hind tibial spur about five-twelfths, and the shorter spur one-third, the length of the basal joint of the hind tarsus. *Abdomen*: the 1st tergite (fig. 1) in basal third smooth and excavated, towards apex of median third strongly tumescent, in apical third, which is turned over and down, rugose or rugulose (except medianly towards apex), the apex emarginate; 2nd tergite (fig. 1) with the median area raised, shining, and entirely smooth, the remainder of the triangular disc impressed and rugose or rugulose; 3rd tergite virtually entirely smooth, longer than the 2nd; ovipositor sheaths (fig. 2) just shorter than the basal joint of the hind tarsus; hypopygium (fig. 2) prominent, the apex acute but not strongly so, and the extreme tip of apex cut away and obtuse.

*Length*, 2·5 mm.

SOUTHERN NIGERIA: 26 ♀♀, 1♂, and 3 indeterminable, 17.vi.1913 (*Dr. W. A. Lamborn*).

*Type* deposited in the British Museum.

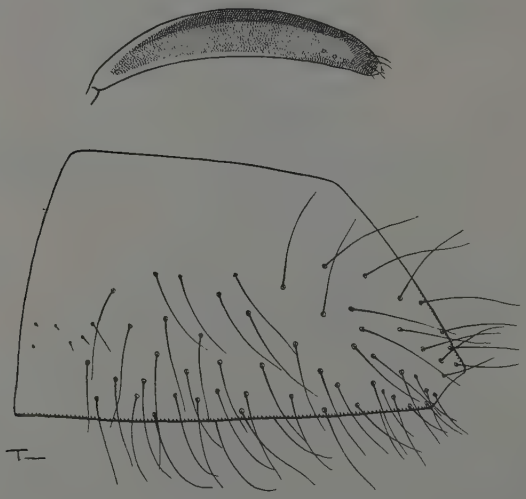


Fig. 2. *Apanteles pistrinariae*, sp. n.: ovipositor sheath and hypopygium (on same scale).

*Host*. Larvae of the Pierid butterfly, *Mylothris chloris*, F. Dr. Lamborn in his collecting notes says: "The larvae which here feed on *Funtumia elastica* are very heavily parasitised in this way. Of fourteen kept under observation since 8th June no less than ten yielded these parasites, and all died subsequently. The number of parasites to each larva varied between nine and sixteen. All left their host by the soft tissues of the ventral surface."

*Cocoons*, pale buff, arranged, like a pile of drain-pipes, regularly one above the other so that both ends are exposed. Dr. Lamborn remarks that the cocoons seem to be so arranged that practically all the imagines emerged at the same side.

The unusual form of the 1st tergite, although a character whereby the species may be immediately separated from all others, renders the satisfactory placing of this species in my key a difficult matter. For the moment I have placed it at the extreme beginning, before the couplets giving the major group-characters.

**Apanteles pistrinariae nyasaensis,** subsp. n.

♀♂. Differs in colour from the original description of *A. pistrinariae* as follows.—All tergites black; tegulae normally, but not invariably, strongly darkened to black; hind femora often darkened at extreme apex.

♀♂. Agrees in sculpture with the original description of *A. pistrinariae* except as follows.—*Wings*: 1st abscissa of radial shorter than breadth of stigma, equal to or rather longer than, never shorter than, the transverse cubital, longer than the recurrent; apical portion of 1st abscissa of the cubital equal to or rather longer than pigmented portion of 2nd abscissa, this latter about equal to upper portion of basal vein, but these veins variable, often all equal; stigma equal to metacarp; the 1st abscissa of radial always angled with transverse cubital, and almost invariably with a stump or a streak of pigment at their point of junction.

*Length*, 2·5 mm.

NYASALAND: Mt. Mlanje, 12 ♀♀ (one the *type*), 4 ♂♂, 8.vii. 1913,and 14 ♀♀, 25 ♂♂, 7.vii.1913 (*S. A. Neave*).

*Type* deposited in the British Museum.

*Host* unknown; the specimens dated 8.vii.1913 labelled "F," the others labelled "I."

*Cocoons* agree exactly in their method of arrangement, but are rather paler than those of *A. pistrinariae*.

An examination of the female external genitalia (fig. 2) failed to reveal even a minute difference between those of the above series and the series from Nigeria.

**Apanteles eucosmae,** sp. n.

♀♂. Black; legs (except as below), 3rd tergite usually and 4th tergite occasionally (except in the ♂♂), the pleurites (except towards apex of abdomen), and the lateral membraneous margin of the 2nd tergite, red testaceous; the hind coxae in basal half, the apical two-fifths of the hind tibiae, the hind tarsi for the most part, darkened, mouthparts, tegulae, tibial spurs, and lateral membranous margin of 1st tergite, testaceous; stigma and most wing veins light brown; stigma without basal cloud; wings slightly and evenly infumated.

In the ♂♂ the hind coxa is almost completely darkened, while the four front coxae also exhibit certain darkening; the tergites are more generally darkened than in the ♀♀.

♀♂. *Head*: face minutely punctate; clypeus definitely differentiated; the toruli considerably nearer to apex of clypeus than to the eye; the posterior ocelli rather nearer to each other than to the eyes; the frons virtually impunctate and smooth, the vertex nearly so. *Thorax*: mesonotum punctate anteriorly (degree 2 or even possibly 3), but posteriorly, together with the disc of the scutellum, only minutely punctate or even smooth; propodeon virtually impunctate, shining, more or less smooth, with a median longitudinal carina throughout its length. *Wings*: the 1st transverse cubital straight, and the 1st abscissa of the radial rounded, the point of junction of these veins indeterminable but the former apparently the longer, their combined length double the length of the recurrent, this latter shorter than the breadth of the stigma; the apical portion of the 1st abscissa of the cubital three-fifths the length of the recurrent, equal to the upper portion of the basal vein, rather longer than

the pigmented portion of the 2nd abscissa of the cubital; stigma definitely shorter than metacarp. *Legs*: hind coxae on outer faces and basally above smooth and highly polished save for some extremely minute, scattered, more or less sparse punctation; the longer hind tibial spur seven-, and the shorter spur five-thirteenths the length of the basal joint of the hind tarsus. *Abdomen*: 1st tergite (fig. 3) with median length twice basal breadth, parallel-sided in about basal two-thirds, thence narrowing gradually to the truncate or slightly emarginate apex, where the breadth is three-fifths the basal breadth, rather indefinitely punctate or sculptured along the extreme margins of the apical half and in the apical fourth or third, otherwise smooth and shining, with the basal two-thirds slightly hollowed and the apical third slightly turned over and down; 2nd tergite (fig. 3) slightly shorter than the 3rd, to some extent arcuately emarginate, discally with two strongly marked, virtually straight, slightly diverging sulci which extend the full length of the tergite and which enclose a perfectly

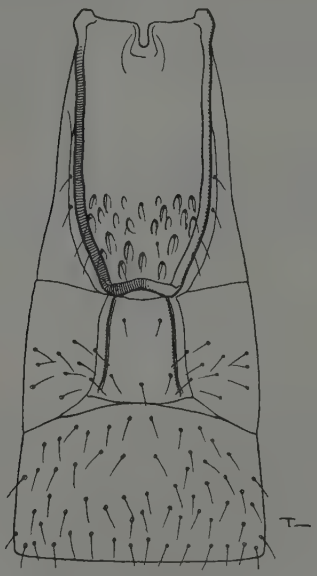


Fig. 3. *Apanteles eucosmae*, sp. n.: 1st, 2nd and 3rd tergites.

smooth area whose base is slightly narrower than the apex of the 1st tergite, and whose median length (equal to the median length of the tergite) is equal to its breadth at apex; ovipositor sheaths rather long, but apparently not half length of abdomen; hypopygium acute, extending beyond apex of abdomen (fig. 4).

*Length*, 2·5 mm.

NIGERIA: Ibadan, 18 ♀♀ (one the *type*), 2 ♂♂, and 2 damaged specimens, 15 & 18.viii.1920 (*A. W. J. Pomeroy*). BELGIAN CONGO: 4 ♀♀, 5 ♂♂, 7.vi.1918 (*R. Mayné*).

*Type* deposited in the British Museum.

*Host*. The series from the Belgian Congo is labelled as parasitic on the Arctiid moth, *Diacrisia mundata*, Walk. The Nigerian series is without host record.

*Cocoons.* The cocoons are contained within a spherical mass of white fluff, as in *Apanteles badgleyi*, Wilkn.

In my revised key this species runs with *A. fuscinervis*, Cam., from which it is easily separable by the shape and sculpture of the 1st and 2nd tergites, and by venational characters. In many respects this species also resembles *A. belippae*, Rohw., particularly as the sheaths are unusually long for this section of *Apanteles*. I have, therefore, considered it wise to place *eucosmae* also in the *belippae* group in my revised key, where I have separated them by the presence or absence of the median longitudinal carina on the propodeon.

Since the above was written, and shortly before going to press, I received of this species from Uganda, Kampala, 38 ♀♀, 4 ♂♂, 15.v.1928, and 16 ♀♀, 21.ix.1927 (*H. Hargreaves*).

Of these two series, the former is labelled "*ex* caterpillar on mpindi leaf," and the latter "*ex* Arctiid larva, ? *Spilosoma*, on *Bauhinia*." I am informed that the Arctiid genera *Spilosoma* and *Diacrisia* are synonymous.

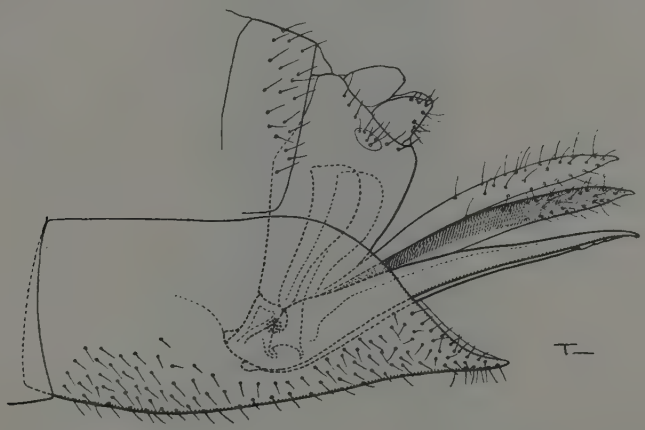


Fig. 4. *Apanteles eucosmae*, sp. n.: apex of abdomen, showing ovipositor and sheaths, and hypopygium.

**Apanteles neavei,** sp. n.

♀♂. Black; front legs (except possibly coxae which are somewhat darkened), middle legs (except coxae), hind femora, basal half or three-fifths of hind tibiae, basal ventrites, palpi and tibial spurs, extreme apex of middle coxae, and also often of the hind coxae, red testaceous; extreme apex of hind femora, apical half or two-fifths of hind tibiae, hind tarsi, darkened; costal veins, stigma, and metacarp, of an uniform, fairly dark reddish-brown, the tegulae of much the same colour; wings hyaline.

♀♂. *Head*: face minutely punctate (degree 1), the facial depressions distinctly nearer to apex of clypeus than to eyes; clypeus differentiated; frons impunctate, smooth, as is vertex except for some minute punctures towards sides. *Thorax*: mesonotum punctate (degree 3), the punctures more closely placed and stronger anteriorly, posteriorly weaker and inclined to be indefinite; scutellar sulcus strongly impressed, crenulate, straight; disc of scutellum with some minute punctures; propodeon with a well marked median longitudinal carina, in basal half otherwise

smooth, in apical half with numerous irregular rugulose carinae which are not closely placed (except possibly towards the middle). *Wings*: 1st abscissa of radial equal in length to the breadth of the stigma, slightly curved, longer than and scarcely angled with the straight transverse cubital, this latter equal to the recurrent; apical portion of 1st abscissa of the cubital decidedly shorter than the recurrent, barely longer than the pigmented portion of 2nd abscissa of the cubital, this latter about equal to upper portion of the basal vein; stigma decidedly shorter than metacarp. *Legs*: hind coxae for the greater part finely closely rugose (or closely aciculate), entirely smooth only in a narrow median longitudinal area on outer faces, basally above with some well marked, separated punctures (degree 3–4); the longer hind tibial spur one half, and the shorter spur rather greater than one-third, the length of the basal joint of the hind tarsus. *Abdomen*: 1st tergite (fig. 5) excavate in basal

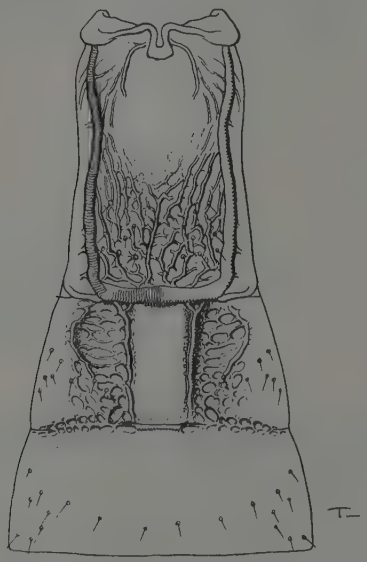


Fig. 5. *Apanteles neavei*, sp. n.: 1st, 2nd and 3rd tergites.

half, where in the middle it is more or less smooth, and where laterally it has fine aciculation, in apical half turned over and down and decidedly rugose, but not very strongly; 2nd tergite (fig. 5) virtually smooth save for its broad and deep sulci, but commonly with some indefinite aciculation on the median area, which area is somewhat higher than the lateral areas; 2nd suture well marked; 3rd tergite longer than 2nd, and, as the succeeding tergites, entirely smooth save for an occasional minute puncture; ovipositor sheaths short, the hypopygium truncated.

*Length*, 2·5 mm.

NYASALAND: Mt. Mlanje, 23 ♀♀, 3 ♂♂, 30.v.1913 (*S. A. Neave*).

*Type* deposited in the British Museum.

*Host* unknown; specimens labelled "H."

*Cocoons* unknown.

This species and *Apanteles mlanje*, sp. n., on account of the form and sculpturing of their 1st and 2nd tergites, differ from any species that I have seen and constitute by themselves a subgroup, which I have placed, provisionally, near the beginning of my second major group.

**Apanteles mlanje,** sp. n.

♀♂. Black ; all legs (including coxae), the greater part of the scape, costal veins, basal ventrites, extreme lateral margins of basal tergites, red testaceous ; tegulae variable, red testaceous or darkened ; apical two-fifths of hind tibiae, and hind tarsi, slightly darkened ; flagellum dark red-brown ; stigma and metacarp of an uniform, fairly dark red-brown ; wings hyaline.

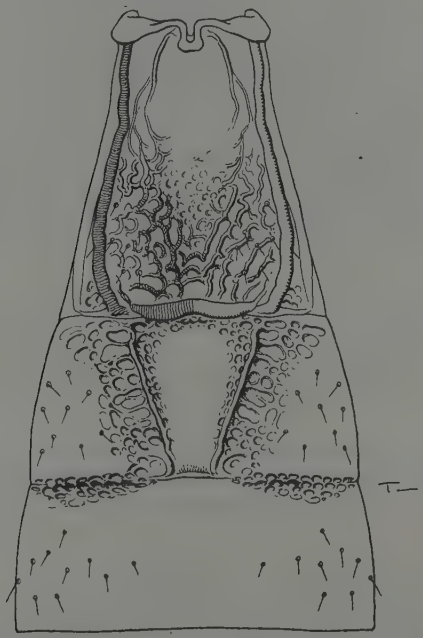


Fig. 6. *Apanteles mlanje*, sp. n.: 1st, 2nd and 3rd tergites.

♀♂. *Head* : face minutely punctate (degree 1), the facial depressions nearer to apex of clypeus than to eyes ; clypeus differentiated ; frons and vertex smooth, save for a little minute punctation. *Thorax* : mesonotum punctate (degree 3), the punctures more closely placed and stronger anteriorly, posteriorly weaker and inclined to be indefinite ; scutellar sulcus strongly impressed, crenulate, straight ; disc of scutellum punctate (degree 2–3), the punctures often indefinite ; propodeon with a well marked median longitudinal carina, and in basal half indefinitely punctate, in apical half with numerous irregular rugulose carinae which are not closely placed (except possibly towards the middle). *Wings* : 1st abscissa of radial slightly curved and its point of junction with the straight transverse cubital more or less indeterminable, equal to the transverse cubital, or at least the combined length of these two twice as great as the breadth of the stigma ; apical portion of 1st abscissa of the

cubital two-thirds the transverse cubital, equal to or rather longer than the pigmented portion of the 2nd abscissa of the cubital, equal to or even sometimes shorter than upper portion of the basal vein, shorter than, rarely equal to, the recurrent; stigma shorter than metacarp; venation rather variable, but characterised by the length of the upper portion of the basal vein. *Legs*: hind coxae basally above punctate (degree 3), the punctures sometimes indefinite, above in apical half with exceedingly fine aciculation, on outer faces virtually smooth, below minutely rugose; the longer hind tibial spur rather more than one-half, and the shorter spur rather less than one-third, the length of the basal joint of the hind tarsus. *Abdomen*: 1st tergite (fig. 6) in about basal third slightly excavate and more or less smooth and shining, in apical half rugose, slightly turned over, and with a broad median area which reaches almost to apex and which is decidedly raised or even broadly tumescent, the narrow lateral areas often appearing almost as sulci between the raised median area and each strong lateral carina; 2nd tergite (fig. 6) with the median area minutely sculptured particularly along the lateral margins and basally, medianly smooth, or even more or less entirely smooth, the discal sulci strong, crenulate, somewhat broader basally, or the sulci even shallow and hardly sculptured and merging into the lateral areas, the lateral areas with some indefinite punctation (degree 2–3) varying to minutely punctate (degree 1); the weaker sculpturing on this tergite more commonly met with (but not entirely) in the males, and the stronger more commonly (but not entirely) in the females, the sulci however always very evident, with the median area raised; 2nd suture strong; 3rd tergite equal in length to 2nd, and, as succeeding tergites, smooth with occasional minute punctures; ovipositor sheaths short; hypopygium very slightly acute, almost truncated.

*Length*, 2·5 mm.

NYASALAND: Mt. Mlanje, 19 ♀♀ (one the *type*), 11 ♂♂, 15.v.1913, and 21♀♀, 12 ♂♂, 25.v.1913 (*S. A. Neave*).

*Type* deposited in the British Museum.

*Host* unknown; the specimens dated 15.v.1913 labelled "M," the others labelled "B."

*Cocoons* unknown.

This species and *Apanteles neavei*, sp. n., are related, differing from one another notably in the colour of the hind coxae and in the shape of the median area of the 2nd tergite.

**Apanteles jujubae,** sp. n.

♀. Black; scape, tegulae, costal vein and other veins in basal half of wing, the four anterior legs (except the bases of the coxae), the hind trochanters and tronchantins, the basal two-thirds or certainly three-fourths of the hind femora, the basal five-eighths of the hind tibiae, the basal sternites and pleurites, and the 2nd and 3rd tergites, red testaceous; mouthparts and tibial spurs pale; flagellum dark brown; stigma, metacarp, 1st abscissa of radial, the transverse cubital, and the pigmented portion of the 2nd abscissa of the cubital, brown, the former with possible indication of hyaline cloud at extreme base.

♂. Agrees with the colour description of the female except that the 2nd tergite is black, as is the apex of the 3rd tergite; the lateral membraneous margins of the basal tergites are however red testaceous as in the female.

♀♂. *Head*: face with sparse indefinite punctation; clypeus not definitely differentiated; toruli large, rather nearer to the apex of the clypeus than to the eyes; posterior ocelli about equidistant from each other and from the eyes, except in the male where they are rather closer to each other. *Thorax*: mesonotum with strong, rather close but definitely separated punctation (degree 4–5); mesopleurae anteriorly

punctate, otherwise entirely smooth and highly shining; disc of scutellum smooth and highly shining save for a few scattered, strong punctures; propodeon with well-marked transverse basal carinae, to which from the median apex of the propodeon carinulae radiate, the intermediate spaces smooth and shining. *Wings*: the transverse cubital longer than, rarely equal to, and definitely angled with, the 1st abscissa of the radial, equal to the recurrent, about twice as long as the pigmented portion of the 2nd abscissa of the cubital, this latter somewhat shorter than the apical portion of the 1st abscissa of the cubital, and somewhat longer than the upper portion of the basal vein; the breadth of the stigma from 1·2 to 1·4 times as great as the length of the recurrent; stigma in length equal to metacarp. *Legs*: hind coxae reaching to about middle of 3rd tergite, basally above with strong, separated punctures (degree 4), on lateral faces with well-marked but weaker and more widely separated punctures (degree 3), the interspaces highly polished, towards apex above weakly rugoso-striate; hind tibial spurs subequal, the shorter half the length of the basal joint of the hind tarsus. *Abdomen*: 1st tergite more or less smooth in basal half and excavated, somewhat rugosely tumescent medianly, and in the apical half rugoso-punctate and weakly turned over and down, with the median length 1·7 times the basal breadth and 1·25 times the apical extreme breadth, parallel-sided in the basal half, thence gradually widening to the somewhat emarginate apex, with the apical angles rounded; 2nd tergite with its lateral sulci rounded, well-marked, rugose, reaching to the well-marked and rugose 2nd suture, its disc more or less rugulose, with extreme breadth twice median length; 3rd tergite entirely smooth, with median length 1·4 times that of the 2nd tergite (except in the ♂ where it is barely longer than the 2nd tergite); ovipositor sheaths short.

*Length*, 2·5 mm.

India: Namkum, Bihar & Orissa, 12 ♀♀, 2 ♂♂, undated (*Lac Research Institute*).

*Type* deposited in the British Museum.

*Host*. The series is labelled, "on Ber leaves."

*Cocoons* white, closely packed in a gregarious mass of dimensions 10×8×5 mms., with a certain amount of white fluff.

This species runs in my revised key to *rubecula* and *cheesmanae*: from the latter it may easily be separated on the colour of the scape and the shape of the 1st tergite and of the stigma, and from the former by the shape of the 1st tergite and by the colour of the scape and of the tegulae.

Of the various species to which *jujubae* could run in the key if it were found that the darkening of the apex of the hind femora was an unstable character, *rufiventris*, *hypsipylae*, and *tiracholae* are the only species that need be considered: the new species is clearly distinct from the first if only on the shape, coloration, and sculpture of the 2nd tergite, from the second on the shape of the 1st tergite, and from the last on venational characters. Of the remaining species in this group, *anthelae* is distinct on account of, *inter alia*, its almost smooth hind coxae and black scape, and *effrenus* on account of the shape of its 1st and 2nd tergites.

**Microgaster plecopterae,** sp. n.

♀♂. Black; antennae, mouthparts, the four anterior legs from the trochanters, hind trochanters and trochantins, hind femora (except towards apex which is darkened), about basal half of hind tibiae, hind tarsi more or less, all tibial spurs, tegulae, costal vein, 1st, 2nd, and 3rd abdominal segments, red or red testaceous; the mouthparts and tibial spurs commonly pale; hind femora often much darkened in apical half; the flagellum normally darkening in apical half or two-thirds, or even altogether brownish; the 2nd and 3rd tergites often darkened, the 1st never; the four anterior coxae variable between completely red testaceous to black; stigma

uniformly dark brown, as are the 1st abscissa of the radial, the 1st transverse cubital, and the 2nd abscissa of the cubital; the nervulus, and the medial vein in the neighbourhood of the basal portion of the 2nd abscissa, strongly darkened; metacarp brown in apical half, more or less testaceous in basal half; 2nd transverse cubital hyaline; forewing lightly but definitely infumated at apex, the infumated area covering about the apical two-fifths of the radial, apical half of the 3rd cubital, and the upper apical third of the 2nd discoidal cells, otherwise more or less hyaline; hindwing lightly infumated at apex; ♂♂ with the infumation of the wings decidedly weaker or even altogether absent.

♀♂. *Head* with close, strong punctation, and in addition to some extent aciculated; facial depressions considerably nearer to apex of clypeus than to eyes; posterior ocelli about equidistant from each other and from the eyes. *Thorax*: mesonotum, and mesopleurae (except above medianly), with strong (degree 5), very close, even, almost reticulate or rugose punctation; disc of scutellum strongly margined at apex, punctate as the mesonotum; propodeon rugosely reticulate, with a strong median longitudinal carina which is more or less crenulate narrowly down each side. *Wings*: venation inclined to be variable; the recurrent in length two-thirds the breadth of the stigma, normally equal to the transverse cubital, shorter than the radial, normally

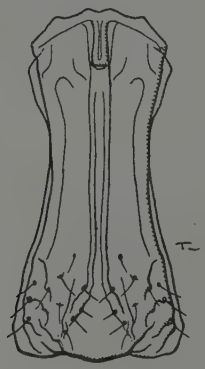


Fig. 7. *Microgaster plecopterae*, sp. n.: 1st tergite.

longer than the apical portion of the 1st abscissa of the cubital, this latter longer than the combined length of the pigmented portions of the 2nd and 3rd abscissae of the cubital, which length is about equal to the upper portion of the basal vein; the recurrent, the 1st transverse cubital, and the apical portion of the 1st abscissa of the cubital, occasionally all equal, even occasionally with the former shorter than the latter; the 2nd transverse cubital minute, received into the 1st transverse cubital rather above its centre, where this latter is commonly, but not always, slightly angled; stigma in length equal to metacarp. *Legs*: hind coxae reaching to apex of 2nd tergite, on outer faces punctate as the mesonotum, on inner faces rugose; the longer hind tibial spur rather less than three-fourths, and the shorter spur about half, the length of the basal joint of the hind tarsus. *Abdomen*: 1st tergite (fig. 7) in apical half rugose, with a deeply impressed, broad, smooth, median, longitudinal sulcus extending from the base almost to the apex of the tergite; 2nd tergite with indications of a smooth raised median area, otherwise, as the succeeding tergites, smooth save for some minute punctation; ovipositor sheaths (fig. 8) with process.

*Length*, 3 mm.

INDIA: Chichawatni Plantation, Punjab, 14 ♀♀, 13 ♂♂, and 2 of indeterminable sex, 14.v.1928 (*type*), 28–30.iv.1928, 2–29.v.1928, 20–22.vi.1928, 9–10.vii.1928, 9–30.viii.1928, 5.ix.1928 (*R. N. Mathur*).

*Type* deposited in the British Museum.

*Host*. Recorded by Dr. Beeson as bred from the Noctuid moth, *Plecoptera reflexa*, Guen.

*Cocoons* white.

This species runs to *M. perniciosa*, Wilkn., in my key to the Indo-Australian and Ethiopian species (Trans. Ent. Soc. London, lxxvii, 1929), from which it is easily separable if only by the processes on the sheaths of the ovipositor. An occasional specimen of *M. plecopterae* that has the four anterior coxae and the hind femora more

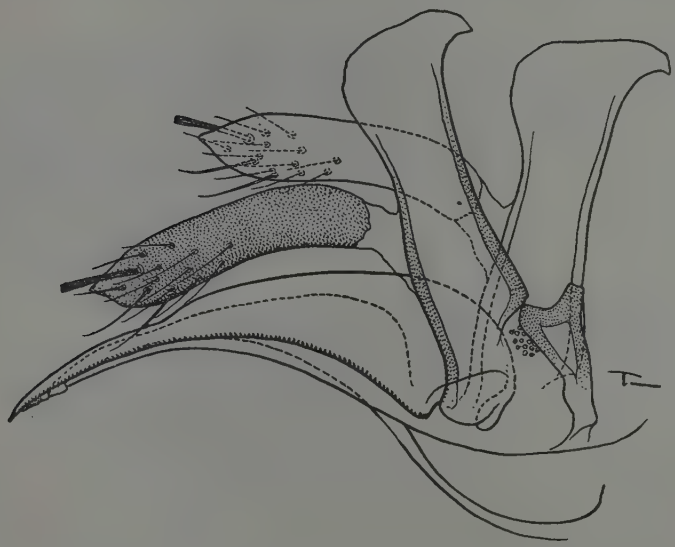


Fig. 8. *Microgaster plecopterae*, sp. n.: ovipositor and sheaths.

extensively darkened might possibly be taken to belong more rightly to the second part of couplet No. 13, whence it would run to *M. fasciipennis*, Gahan, and *M. persimilis*, Wilkn.; from these latter, however, it would be distinct on account of, *inter alia*, its testaceous tegulae and distally broadened 1st tergite.

**Disophrys sissoo**, sp. n.

♀♂. Red testaceous; scape externally or even wholly, flagellum, and ovipositor sheaths, black; extreme apex of hind tibiae commonly, and hind tarsi occasionally, slightly darkened; head and abdomen (except 1st tergite) occasionally rather strongly darkened; wings basally with veins red testaceous, apically strongly infuscated, with the extent of the infuscation not noticeably variable; basal half (about) of the stigma red testaceous.

♀♂. *Head*: flagellum with 39–40 joints, the 1st joint slightly longer than the 2nd; face transverse, with some indefinite punctation; toruli large and deep, somewhat nearer to the eyes than to apex of the clypeus, the distance between them about twice as great as the distance between the toruli and the eyes, this latter about equal to the length of the cheeks; distance between a posterior ocellus and the eye in the ♀ about equal to, and in the ♂ rather greater than, the breadth of an ocellus. *Thorax*: mesonotum with some indefinite punctation; notauli well marked and complete, usually lightly crenulate; scutellar sulcus large and deep, with definite but weak crenulation; disc of scutellum with a minute but definite transverse carina at apex; propodeon completely areated with the arrangement of the carinae much as in *D. diluta*, Turn., and *D. lutea*, Brullé, namely with two median longitudinal carinae (which join with each other both at base and apex thus forming an elongate pointed area), and on each side a longitudinal carina both before and after the spiracle, together with an equally well-marked, transverse carina at about the middle

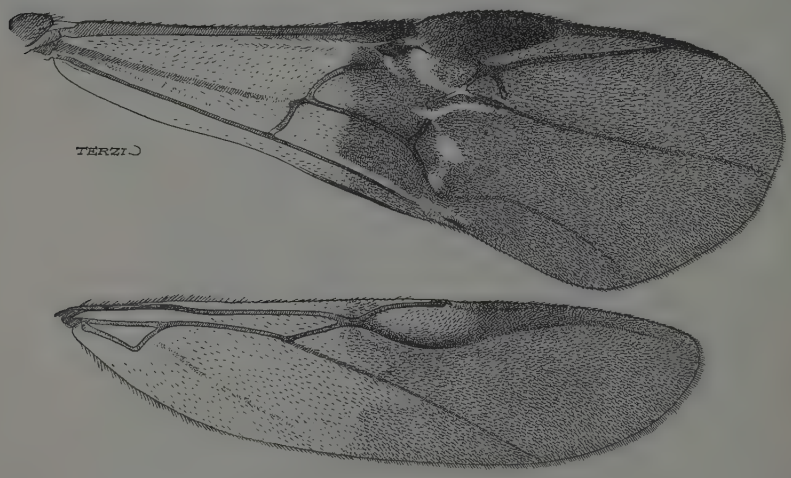


Fig. 9. *Disophrys sissoo*, sp. n.: fore and hind wing.

of, or at the apex of the basal three-fifths, of the propodeon, and another but weaker transverse carina more towards the base; propodeon occasionally decidedly angled at the apical transverse carina; areation and carination of propodeon variable. *Wings* with venation and infuscation as shown in fig. 9. *Legs* with all claws with small tooth. *Abdomen*: 1st tergite with median length twice apical breadth and 3·5 times basal breadth, with prominent spiracular tubercules at apex of basal third; ovipositor sheaths apparently about as long as the longer hind tibial spur.

*Length*, 6–7 mm.

India: Chichawatni Plantation, Punjab, 6 ♀♀, 4 ♂♂, 12–29.vi.1928, 7.vii.1928 (*type*), 1–28.vii.1928 (*R. N. Mathur*).

*Type* deposited in the British Museum.

*Host*. Recorded by Dr. Beeson as bred from larvae of the Noctuid moth, *Plecoptera reflexa*, Guen., on *Dahlbergia sissoo*.

This species closely resembles *D. diluta*, Turn. (N. Queensland), which has, however, the forewings virtually bifasciated and whose hind tarsi are completely and decidedly darkened. *D. exornata*, Turn. (N. Queensland) is also closely related, but differs in the more extensive and darker infuscation of the wings and in the black hind tarsi.

At the moment I am only able satisfactorily to separate *D. lutea*, Brullé (Africa), from *D. sissoo* on the coloration of the wings, the former species having the forewings hardly infuscated and with the costa black ; but I received with the remainder of this bred series from India a specimen with wings agreeing absolutely with those of *lutea*, so that it would appear to be possible for *D. sissoo* in time to be shown to be only a subspecies or variety of Brullé's well-known and widely distributed African species.

# ON THE PART PLAYED BY PARASITES IN THE CONTROL OF INSECTS LIVING IN PROTECTED SITUATIONS. (1)

By W. R. Thompson, Ph.D., D.Sc.,
*Imperial Bureau of Entomology.*

Among the injurious insects with which the entomologist attempting to utilise the methods of biological control has to deal, there are many which live in such a way that a considerable proportion of their population is practically inaccessible to parasites and predators, even during the stages when they are attractive to their enemies. Insects of this type are not infrequently transported in their animal or vegetable food materials into other territories, escape attention during the process of inspection, and develop in their new homes into devastating pests. The Mediterranean Fruit Fly, the Codling Moth, and the European Corn Borer are familiar examples of this class of pest.

When insects of this kind are studied in their original habitat, it is often found that they are only slightly attacked by parasites. This fact is attributed, not without reason, to the protected situation in which they live and is sometimes interpreted as meaning that in such cases the rôle of parasites as controlling agents is insignificant and their value in the new habitat likely to be small, because it seems impossible that a parasite attacking a host, only part of whose population is accessible, can ever overtake it, bring it under control and prevent its further increase. It seems, therefore, worth while to examine the question with some care, in order to decide exactly what part parasites play in the natural control of pests living in protected situations.

It is clear, to begin with, that parasites or predators destroying only a small proportion of the host population, are not necessarily unimportant. Even if a parasite destroys only 1 per cent. of the females of the host species, its absence would transform a numerically stable population into one with a two-fold rate of increase in every generation. A population increasing in geometrical progression at this rate would very soon become a devastating pest.

Parasites destroying a small proportion of the host species are not always, of course, as important as this. As we have pointed out in a previous paper, the value of any controlling factor depends, not only on the fraction of the total host population it destroys, but also on the fraction for the destruction of which it is *indispensable*. There are certain factors, such as the various meteorological agencies, which, when acting at a given intensity, will destroy about the same proportion of individuals of a given species, whatever be the size of the population. If factors of this type, acting in this way, come into operation after the parasite has done its work, its disappearance may have much less effect than one would expect, because a certain number of individuals killed by the parasite when it is present would succumb in any event. If we designate the proportions of the host population, at the time of observation, killed by the parasite and the general factors respectively, by $a$ and $b$, the total mortality produced by the combined action of the two will be :—

$$M = a + (1 - a)b.$$

This is a case where the individuals killed by the non-parasitic factor are distributed uniformly through the whole population. They might, however (to take only the simple cases) be individuals all belonging to a certain group of the population, which might be (1) accessible, or (2) inaccessible to parasitic attack ; or (3), they might actually comprise in their number the very individuals which the parasite would have killed if it had been present.

(1) Contributions from the Farnham House Laboratory, Imperial Bureau of Entomology, No. 1.

In the first case, where the non-parasitic factor affects only individuals of the group accessible to parasitic attack, the disappearance of the parasite would have the same effect as in the first instance studied, the action exerted by both factors being, however, confined to the group of accessible individuals, the inaccessible group being unaffected by either factor in any event.

In the second case, since the factors act on separate and distinct groups, the disappearance of the parasite will, obviously, save all the individuals it would have destroyed.

In the third case, since the non-parasitic factor destroys, among other individuals, those that would have been killed by the parasite had it been present, it seems that the latter, in spite of its apparent effect, would be in reality absolutely valueless, and that its disappearance would cause no change whatever. This is, however, not necessarily true. If the non-parasitic factor destroys the same proportion of hosts, whether the parasite is present or not, the fact that all the specimens killed by the parasite would in its absence be killed by the non-parasitic factor is immaterial. Thus suppose we have 100 hosts of which the parasite kills 10 per cent., while the non-parasitic factor destroys 50 per cent. of the remainder. The total absolute destruction will then be 55 per cent., or 5 per cent. more than if the non-parasitic factor had been acting alone. The course of events is thus the same as if the individuals destroyed by the non-parasitic factor were distributed uniformly through the population. If the proportion of hosts destroyed by the non-parasitic factor was diminished by the number killed by the parasite, the same proportion of the total population would be destroyed by the physical factor alone, as by the physical factor and the parasitic working together. This would mean that the individuals attainable by the parasite always form part of the total population actually destroyed by the non-parasitic factor. In such a case the work of the parasite would be valueless. Such a contingency is, however, unlikely, because, other things being equal, physical factors tend to destroy the same proportion of the population, whatever be its numerical value.*

It is thus evident, that even though the proportion of the insect population destroyed by parasites or predators is small, it is not necessarily nor even probably, unimportant. Other things being equal, the disappearance of even a minor parasite would, sooner or later, be followed by an outbreak of the host. Therefore, if an insect, which is relatively innocuous in its native home, develops into a serious pest when introduced into a new habitat, it is reasonable to suppose that this is due to the absence of its parasites and predators, even though these destroy only a small proportion of the population because of the protected situation in which the insect in question lives ; and it is also reasonable to expect that the introduction of the parasites from the country of origin will prove an effective remedy.

During the period following immediately upon its introduction the parasite will increase and spread at the expense of that part of the host population which is accessible to attack ; and during this time the inaccessible portion may be considered as exactly equivalent to the accessible population in excess of the parasite's requirements, escaping attack simply for that reason. There does not seem to be any reason

* If two parasites acting in succession, attack exactly the same group of individuals and the second species is present in such numbers and so widely distributed that it is capable *alone*, of killing all the hosts in the group mentioned, then the action of the first species would be superfluous, or, to put it more exactly, neither of the parasites, considered separately, would be indispensable as causes of destruction in relation to the individuals which either is capable of killing, so long as both are present. In this case, the first species might disappear without any change resulting. Thus, suppose that a certain insect is attacked in the egg stage by a Chalcid, and that the particular eggs attractive to the Chalcid, all develop into larvae attractive to an Ichneumonid, which is capable of killing *all* the individuals of this type including those which would be killed by the Chalcid if it were present. In such a case, the work of the Chalcid would be valueless. This seems to be the only case in which a parasite can definitely be considered as useless. For obvious reasons, such cases are not likely to occur very often.

why the parasite should not increase until its numbers are equal to the accessible population. Up to this time the general problem does not differ essentially from those studied in former papers.

The progress of events after this point where the parasite population is equal to the host requires more careful consideration.

In the first place, after the parasite population reaches the point where it is equal to the host population, the eggs and larvae in excess of those required to destroy the accessible hosts, will not necessarily be retained by the ovipositing females, but will be more probably deposited in individuals which are already parasitised. If this occurs there will be a considerable loss through superparasitism owing to the fact that many hosts contain so many parasites that they cannot complete their development. The writer has seen a small colony of *Lophyrus* so heavily attacked by a Tachinid parasite that both host and parasites succumbed, so that this possibility is not merely theoretical. The mortality arising from superparasitism will of course depend, other things being equal, upon the relation between the number of accessible hosts and the number of eggs deposited on the one hand, and, on the other, on the number of parasites which one host can nourish in an adequate manner.

The problem of the actual number of individuals so lost in any given case is difficult and requires the determination of the probable number of host individuals containing more than $n$ parasites, when $x$ parasites are distributed at random among $y$ hosts.

Without considering this point at present, let us suppose that one living parasite emerges from each infected host, no matter how many eggs are deposited therein, and proceed on this basis.

Let $n$ represent the initial number of host adults, $p$ the initial number of parasites present, $h$ the reproductive rate per generation of the host, and $s$ the reproductive rate per generation of the parasite, and let the sex ratios of the host and parasites be equal.

Let $h$ be $=$ or $<s$

In the 1st generation we have

$$H_1 = n \times h = nh \quad \text{hosts and}$$
$$P_1 = p \times s = ps \quad \text{parasites.}$$

Let the proportion of hosts accessible to attack be $=a$ ($a<1$), and the proportion inaccessible $=i$ ($a+i=1$). Suppose now, that we have $ps=nha$, i.e., the number of offspring of the parasite equal to the number of accessible offspring of the host.

Then the number of hosts issuing will be $=nhi$ and the number of parasites issuing will be $=nha$.

Therefore in the second generation we shall have

$$H_2 = nhi \times h = nh^2i \quad \text{hosts and}$$
$$P_2 = nha \times s = nhas \quad \text{parasites.}$$

The accessible host population is now $nh^2ia$.

Now $nh^2ia : nhas = hi : s$; but we have $i<1$ and $h=$ or $<s$. Therefore we have $hi<s$.

The number of progeny of the parasites is thus inferior to the number of progeny of the host.

Now suppose, as suggested above, that *one* living parasite issues from each host attacked, no matter how many eggs have been deposited in it—a position which actually occurs with a considerable number of parasites, such as *Eulimneria crassifemur*, Thoms., *Aphidius* spp., *Sturmia scutellata*, etc., etc.

In that case, the number of parasites emerging will be equal in every generation to the numbers of accessible hosts.

Therefore the hosts emerging in Generation II=$nh^2i^2$ and the parasites emerging $nh^2ia$.

In the third generation we have $H_3=nh^2i^2\times h=nh^3i^2$, of which $nh^3i^2a$ are accessible, and $nh^3i^3$ inaccessible. $P_3=nh^2ia\times s=nh^2ias$, reduced through superparasitism to $nh^3i^2a$.

Thus in general, designating the hosts emerging in the $t^{th}$ generation by $HE_t$, and the parasites emerging in the $t^{th}$ generation by $PE_t$, we have

$$HE_t=nh^ti^t$$
$$PE_t=nh^ti^{t-1}a.$$

Let us now consider the value of $HE_t$. If we have $hi>1$, then, when $t$ is large, $HE_t$ will evidently be very large. In such a case, therefore, the host will go on increasing indefinitely in spite of the presence of the parasites. This will occur for example with host reproductive rates of 100, 40 and 20, if the proportion of hosts which are inaccessible is more than 0·01, 0·025 and 0·05 respectively. The higher the reproductive rate, the fewer the proportion of hosts which must be inaccessible to prevent control.

If we have $hi=1$, then $n(hi)^t=n$, which is to say that the host population remains stable at its initial value. Thus, taking the preceding examples, if the proportion of inaccessible hosts is exactly $\frac{1}{100}$, $\frac{1}{40}$ and $\frac{1}{20}$, respectively, then the host will be definitely brought under control at the point its population had attained when the parasite came to equal it in numbers, since only one of the progeny escapes in each case. Finally, if we have $hi<1$, then $n(hi)^t$ will tend to 0 as the value of $t$ increases. When it falls below 1, the host may be considered to be exterminated. This would occur in the examples mentioned, if less than 1 in 100, 1 in 40 and 1 in 20, respectively, of the hosts were inaccessible, or to put it more simply, if less than 1 of the progeny of each individual host survived.

Let us take some arithmetical examples, examining first the case where we have $hi>1$. Put $h=10$ and $i=0·2$. Therefore $hi=2$. Put $s=10$, $n=10$ and $p=8$. In Generation I, we have $H_1=10\times10=100$, of which $0·8\times100=80$ accessible; $P_1=8\times10=80$. In Generation II we have 20 hosts escaping and 80 parasites issuing. We have therefore $H_2=20\times10=200$ of which 160 accessible and $P_2=80\times10=800$ reduced by superparasitism to 160. In Generation III we have

$H_3=40\times10=400$ of which 320 accessible and
$P_3=160\times10=1{,}600$, reduced by superparasitism to 320 and so on.

The parasitism in each generation remains constant at 80 per cent.; for although the number of parasites increases, the number of hosts also increases.

If we have $p=9$, $i=0·1$ and $hi=1$, then the course of events is as follows:—

G.I: $H_1=10\times10=100$ of which 90 are accessible;
$P_1=9\times10=90$

G.II: $H_2=10\times10=100$ of which 90 are accessible;
$P_2=90\times10=900$ reduced by superparasitism to 90 and so on *ad infinitum*.

The curious thing about this example is that, although generation after generation the parasitism is 90 per cent. and the parasite population always very greatly in excess of the host population, nevertheless, owing to the escape of 10 per cent. of the host population in each generation, the host population will never fall below the point it had attained when the parasite population reached the level of the accessible host population. If the population-level of the host happened to be correlated with economic damage, this would recur indefinitely, other things being equal, in spite of the abundance and apparent efficiency of the parasite.

A case of this kind is actually known. One of the parasites of the Alfalfa Weevil, *Hypera variabilis*, Hbst. (*Phytonomus posticus*, Gyll.) sent from Italy to America in

1911–1913 by W. F. Fiske, H. S. Smith and the writer, increased in numbers until it destroyed in many districts over 90 per cent. of the weevil larvae, the adults being obtained more frequently in sweeping than the adult weevils themselves. Nevertheless, economic damage has apparently not been prevented so that artificial measures of control are still required. It is not suggested that the hypothetical case here studied is exactly like that of the Alfalfa Weevil and its parasites. It does show, however, that cases of this kind, which seem at first sight almost incomprehensible, may have a very simple explanation.

If we have $hi<1$, put $h=10$ and $i=\cdot05$ ; put $s=10$, $n=100$ and $p=95$ : We have in G.I,

$H_1=100\times10=1{,}000$, of which 950 are accessible ;
$P_1=\ 95\times10=950$.

In G.II $H_2=\ 50\times10=500$, of which 475 are accessible ;
$P_2=950\times10=9{,}500$, reduced by superparasitism to 475.

In G.III $H_3=\ 25\times10=250$, of which 237·5 are accessible ;
$P_3=475\times10=4{,}750$, reduced by superparasitism to 237·5.

In G.IV $H_4=12\cdot5\times10=125$, of which 116·75 are accessible ;
$P_4=237\cdot5\times10=2{,}375$, reduced by superparasitism to 116·75, and

so on until the number of hosts becomes less than unity, which may be taken to mean extermination.

It is evident that under the hypothesis taken as a basis for calculation, the actual reproductive rate of the parasite is of no importance so long as the initial number of progeny is equal to the number of accessible hosts.

Thus, other things being equal, it appears that in cases of the type we have studied, the fact that a proportion of the host population is inaccessible may have an extremely serious effect on the progress of its parasites. Even though the parasite reproduces at a rate which enables it to reach the numerical level of the accessible host population in a short time, the fact that a relatively small proportion of the hosts is inaccessible may completely prevent it from establishing control. Although a high percentage of hosts is destroyed in every generation, the host population may maintain itself at a level corresponding to economic damage or even continue to increase. The proportion of inaccessible hosts must be very low if control is to occur, the escape of anything over one-tenth of the population being sufficient, in the example given, to allow of the increase of the pest.

The hypothesis which has been taken as a basis for this study is that one parasite emerges from every host attacked, no matter how many eggs or larvae were deposited therein. This implies a considerable mortality among the parasites from the time when the parasite population becomes equal to the accessible host population. Two other simple hypotheses might be considered ; the first, that where several parasites enter a single host, all die ; the second, that all survive when anything less than a certain number is present in a single host, and that all die when the number is reached or exceeded.

It is, however, evident that neither of these hypotheses is more advantageous to the parasite than the one already examined. If, when more than one parasite enters a single host, all die, then the reduction of the parasite population owing to superparasitism will simply be considerably greater than has been postulated. If the reduction were such that the progeny of the adults issuing was less numerous than the accessible host population, the rate of increase of the host would rise ; if all the parasites developed, in cases where less than a certain number was present in a single host, then the parasite population would increase until this number was reached, without, however, being able to exert any action on the inaccessible host population. After this point, the course of events would be as in the preceding case. The only marked

difference would be that in the period between the time when the parasite population became numerically equal to that of the accessible hosts, and the time when it became so abundant, that severe mortality began to occur through superparasitism, the population of the adult and larval parasites present in the field would be tremendously in excess of the population of the adult hosts, giving an impression of the efficiency of the parasite which would be in reality quite illusory. The only advantage which might result from this excess in the parasite population would be that all of the accessible hosts actually present would be discovered, but the assumption that they are all discovered and attacked, as soon as the parasite population becomes equal in numbers, has been included in the initial hypothesis and is implied in all the subsequent reasoning. It therefore seems legitimate to conclude that the existence of a proportion of a host population inaccessible to the attack of a parasite or predator, or, to put it in another way, the inability of a parasite or predator to attain the host over the whole area of its distribution, may be a very serious matter.

Furthermore, in order to be inaccessible to an enemy, the host need not necessarily live in what are ordinarily called protected situations, such as tunnels in the substance of plants or beneath the surface of the soil. The mere fact that it can live in zones in which the parasite or predator cannot survive, or to which it is not attracted, or may be present at times when its enemies are not in a stage when they can attack it, constitutes an equally efficacious protection, and is the real argument for the introduction of natural enemies belonging to several species in order to control pests imported from other regions.

## COLLECTIONS RECEIVED.

The following collections were received by the Imperial Bureau of Entomology between 1st July and 30th September, 1929, and the thanks of the Managing Committee are tendered to the contributors for their kind assistance :—

Mr. W. Allan :—23 Coleoptera, 6 Hymenoptera, 4 Lepidoptera, and 31 Rhynchota ; from Northern Rhodesia.

Mr. S. F. Ashby :—1 species of Aphidae ; from Kew, Surrey.

Dr. F. S. Bodenheimer :—10 Diptera, 3 Coleoptera, 131 Parasitic Hymenoptera, 2 other Hymenoptera, 4 Rhynchota, 414 Orthoptera, and 2 Ephemeridae ; from Palestine.

Mr. G. E. Bodkin, Government Entomologist :—597 Coleoptera and 133 Ticks ; from Palestine.

Dr. G. Bondar :—92 Coleoptera and 4 Rhynchota ; from Brazil.

Chief Plant Pathologist, Giza :—7 Diptera ; from Egypt.

Mr. L. D. Cleare, Junr., Government Entomologist :—4 *Stomoxys*, 10 other Diptera, 2 Coleoptera, 10 Parasitic Hymenoptera, 100 other Hymenoptera, 150 Isoptera, 1 species of Coccidae, 2 species of Aphidae, 100 other Rhynchota, 3 Orthoptera, 30 Ticks, 20 Mites, 3 Worms, 8 Lizards, and 22 Shells ; from British Guiana.

Prof. T. D. A. Cockerell :—3 Culicidae, 5 Tabanidae, 59 other Diptera, 71 Coleoptera, 51 Hymenoptera, 104 Lepidoptera, 74 Rhynchota, 9 Orthoptera, 3 Ephemeridae, 13 Trichoptera, and 4 Spiders ; from various localities.

Mr. G. H. Corbett, Government Entomologist :—86 Diptera, 50 Coleoptera, 162 Parasitic Hymenoptera, 25 other Hymenoptera, 55 Lepidoptera, 15 Rhynchota, and 4 Orthoptera ; from the Federated Malay States.

Mr. G. S. Cotterell, Assistant Entomologist :—19 Coleoptera, 4 Parasitic Hymenoptera, 8 other Hymenoptera, 17 Lepidoptera, and 6 Rhynchota ; from the Gold Coast.

Mr. A. Cuthbertson, Assistant Entomologist :—14 Diptera, 6 Coleoptera, 11 Parasitic Hymenoptera, and 16 Rhynchota ; from Southern Rhodesia.

Mr. D. d'Emmerez de Charmoy :—25 Coleoptera and 15 Parasitic Hymenoptera ; from Mauritius.

Mr. J. W. Evans :—15 Diptera, 14 Coleoptera, 108 Rhynchota, and 64 Orthoptera ; from Baluchistan.

Prof. J. C. Faure :—3 Culicidae, 30 other Diptera, 630 Coleoptera, 36 Hymenoptera, 26 Lepidoptera, 82 Rhynchota, 436 Orthoptera, and 30 Planipennia ; from South Africa.

Mr. C. Franssen :—2 Coleoptera, 9 Parasitic Hymenoptera, and 5 Rhynchota ; from Java.

Mr. J. C. M. Gardner, Systematic Entomologist :—166 Coleoptera, 65 Parasitic Hymenoptera, and 50 Psyllidae ; from the United Provinces, India.

Mr. F. D. Golding, Government Entomologist :—5 Diptera, 54 Coleoptera, 19 Lepidoptera, 1 species of Coccidae, 4 species of Aphidae, 4 species of Aleurodidae, 327 other Rhynchota, and 25 Psocidae ; from Southern Nigeria.

Mr. P. v. d. Goot :—2 Diptera, 2 Coleoptera, 14 Lepidoptera, and 3 Rhynchota ; from Java.

Mr. W. B. Gurney, Government Entomologist :—3 Coleoptera, 46 Mallophaga, 45 Anoplura, and 7 Mites ; from New South Wales, Australia.

Mr. G. L. R. Hancock, Assistant Entomologist :—60 Culicidae, 6 other Diptera, 506 Coleoptera, 70 Parasitic Hymenoptera, 113 other Hymenoptera, 167 Lepidoptera, 152 Rhynchota, 2 Chrysopidae, and 3 Hemerobiidae ; from Uganda.

Mr. E. Hargreaves, Government Entomologist :—9 Culicidae, 2 Tabanidae, 194 other Diptera and 6 early stages, 59 Coleoptera, 51 Hymenoptera, 45 Lepidoptera, 8 Isoptera, 2 species of Coccidae, 41 other Rhynchota, 35 Orthoptera, 4 Planipennia, and 7 Trichoptera ; from Sierra Leone.

Mr. G. M. Henry, Colombo Museum :—233 Coleoptera ; from Ceylon.

Mr. B. Hergula :—7 Chalcididae ; from Yugoslavia.

Mr. F. G. Holdaway :—36 Parasitic Hymenoptera ; from France.

Mr. G. V. Hudson :—142 Coleoptera and 3 Rhynchota ; from New Zealand.

Mr. H. C. James, Assistant Entomologist :—104 Chalcididae ; from Kenya Colony.

Mr. F. P. Jepson, Assistant Entomologist :—400 Isoptera ; from Ceylon.

Dr. S. Kéler :—5 Cecidomyiidae ; from Poland.

Dr. W. A. Lamborn, Medical Entomologist :—2 Culicidae, 3 other Diptera, 2 Coleoptera, 7 Chalcididae, and 150 Lepidoptera ; from Nyasaland.

Mr. O. B. Lean, Assistant Entomologist :—8 Diptera, 2 Coleoptera and 11 early stages, 4 Orthoptera, 2 Mallophaga, and 14 Mites ; from Southern Nigeria.

Dr. D. Miller, Chief Entomologist, Cawthron Institute :—40 Coleoptera, 1 species of Aphidae, 200 Collembola, and 50 Mites ; from New Zealand.

Mr. N. C. E. Miller, Assistant Entomologist :—54 Coleoptera ; from the Federated Malay States.

Mr. H. M. Morris, Government Entomologist :—23 Diptera, 47 Coleoptera, 36 Hymenoptera, 5 species of Coccidae, and 5 other Rhynchota ; from Cyprus.

Mr. J. Muggeridge :—12 Coleoptera, 28 Parasitic Hymenoptera, 96 species of Coccidae, 4 species of Aphidae, and 13 other Rhynchota ; from New Zealand.

Dr. J. G. Myers :—10 Diptera, 10 Coleoptera, 185 Parasitic Hymenoptera, 9 Lepidoptera, and 3 larvae, 1 species of Aphidae, 45 other Rhynchota, and 5 Dermaptera ; from British Guiana : and 7 Diptera, 3 Coleoptera, 112 Parasitic Hymenoptera, and 4 Anoplura ; from Trinidad.

Mr. A. S. Nicolay :—37 Coleoptera ; from various localities.

Mr. C. B. Philip :—46 Culicidae ; from Lagos, Nigeria.

Mr. G. T. Philpott :—3 Coleopterous larvae attacking tobacco ; from Uganda.

Mr. A. W. J. Pomeroy, Government Entomologist :—25 Culicidae, 20 Tabanidae, 300 *Glossina*, 22 other Diptera, 11 Coleoptera, 3 Hymenoptera, 7 Lepidoptera, 648 tubes of Isoptera, 3 Orthoptera, 7 Planipennia, 5 Trichoptera, 28 Mallophaga, 12 Ticks, 12 Mites, and 3 Earthworms ; from the Gold Coast.

Mr. R. Pussard :—23 Parasitic Hymenoptera ; from France.

Mr. A. Reyne :—4 Coleoptera ; from Java.

Mr. A. H. Ritchie, Government Entomologist :—1 species of Coccidae and 100 Orthoptera attacked by fungus ; from Tanganyika Territory.

Mr. H. C. Sampson :—125 Coleoptera ; from Kew, Surrey.

Mr. A. F. de Seabra :—1 species of Aphidae ; from Portugal.

Mr. H. W. Simmonds, Government Entomologist :—10 Diptera and 13 Hymenoptera ; from the Fiji Islands.

Mr. S. H. Skaife :—85 Orthoptera ; from South Africa.

Mr. C. B. Symes, Medical Entomologist :—91 Culicidae, 25 Anoplura, 12 Ticks, and 5 Mites ; from Kenya Colony.

Mr. R. W. E. Tucker, Entomologist :—4 Culicidae, 9 other Diptera, 6 Coleoptera, 90 Parasitic Hymenoptera, 150 Formicidae, 13 Lepidoptera, 14 Isoptera, 2 species of Coccidae, 5 other Rhynchota, 3 Hemerobiidae, 2 Mallophaga, and 250 Mites ; from Barbados.

Wellcome Tropical Research Laboratories, Khartoum :—60 Culicidae, 14 other Diptera, 1,495 Coleoptera, 5 Parasitic Hymenoptera, and 101 Lepidoptera ; from the Sudan.

# GENERAL INDEX.

## A.

*abietis, Adelges ; Aphidoletes ; Hylobius.*
*abnormalis, Aëdes* (*Aëdimorphus*).
*abruptus, Thyridanthrax.*
*absinthii, Macrosiphoniella.*
*Abutilon*, **414** ; *Platyedra gossypiella* on, in Sudan, **259.**
*Acacia* spp., Coccids on, in Australia, **21, 23, 26, 28, 29, 36** ; Coccids on, in India, **415** ; Coccids on, in S. Rhodesia, **347, 352, 356** ; Buprestid on, in Sudan, **107** ; relation of *Glossina morsitans* to, **289.**
*acaciae, Targionia.*
*Acalypha*, new thrips on, in Sierra Leone, **70.**
*Acanthiophilus hemimelas*, **396.**
*Acanthiophilus muiri*, **396.**
*Acanthiophilus walkeri*, **396.**
*Acer pseudoplatanus*, Aphid on, **433.**
*acerata, Acraea.*
*aciculatus, Microdus.*
*Aclerda sacchari*, on sugar-cane in Peru, **229.**
*Acraea acerata*, parasite of, in Uganda, **104.**
*acraeoides, Castnia.*
*Acrocercops*, Chalcid parasite of, in Philippines, **414.**
*actiosa, Diplosis.*
*Adelges abietis*, Cecidomyiid predacious on, in France, **434.**
*Adelges strobilobius*, Cecidomyiid predacious on, in Italy, **440.**
*Adelgimyza strobilobii*, predacious on Aphid in Italy, **440.**
*Aëdes*, characters of squama of, **343.**
*Aëdes* (*Aëdimorphus*) *abnormalis*, early stages of, **64.**
*Aëdes* (*Finlaya*) *albilabris*, in Solomon Is., **306** ; larva of, **315.**
*Aëdes* (*Stegomyia*) *albolineatus*, breeding-places of, in Solomon Is., **306, 314.**
*Aëdes amesi*, **304, 341.**
*Aëdes* (*Stegomyia*) *argenteus*, **50** ; in Solomon Is., **305.**
*Aëdes* (*Banksinella*) *brugi*, possibly the male of *A. imprimens*, **314.**
*Aëdes* (*Cancraëdes* subgen. n.) *cancricomes*, characters of, **342.**
*Aëdes* (*A.*) *carmenti*, in Solomon Is., **307.**
*Aëdes caspius*, instar records of, **195–198.**
*Aëdes* (*Cancraëdes*) *curtipes*, characters of, **342.**
*Aëdes detritus*, instar records of, **195–198.**
*Aëdes edwardsi* var. *tulagiensis*, **304.**
*Aëdes* (*Chaetocruiomyia*) *elchoensis*, sp. n., from N. Australia, **276.**
*Aëdes* (*Geoskusea* subgen. n.) *fimbripes*, **316** ; characters of, **341.**
*Aëdes* (*Finlaya*) *flavipennis*, in Solomon Is., **315.**
*Aëdes* (*Skusea*) *fumidus*, characters of, **341.**
*Aëdes* (*A.*) *funereus*, characters of, **342.**
*Aëdes funereus* var. *ornatus*, breeding-places of, in Solomon Is., **307, 316** ; characters of, **342.**
*Aëdes* (*Skusea*) *furvus* (*Stegomyia fusca*), characters of, **341.**
*Aëdes* (*Finlaya*) *geniculatus*, breeding in tree-holes in Britain, **49, 54** ; food of larva of, **56** ; instar records of, **195–198.**
*Aëdes* (*Chaetocruiomyia*) *humeralis*, **275.**
*Aëdes* (*Aëdimorphus*) *imprimens*, in Solomon Is., **306** ; *A. brugi* possibly the male of, **314.**
*Aëdes* (*Dendroskusea*) *iyengari*, characters of, **341.**
*Aëdes* (*Finlaya*) *kochi*, in Solomon Is., **306.**
*Aëdes kochi* var. *samoana*, in Solomon Is., **314.**
*Aëdes* (*Skusea*) *longiforceps*, sp. n., from Solomon Is., **307, 315** ; characters of, **341** ; *Dendroskusea* correct subgenus for, **341.**
*Aëdes* (*Rhinoskusea* subgen. n.) *longirostris*, characters of, **342.**
*Aëdes* (*Cancraëdes*) *miachaetessa*, characters of, **342.**
*Aëdes* (*Dendroskusea* subgen. n.) *micropterus*, characters of, **341.**

(8402) Wt P5/3521 1,100 3/30 H & Sp Gp 52

*Aëdes* (*Chaetocruiomyia*) *moloiensis*, sp. n., from Queensland, **276.**
*Aëdes notoscriptus*, **315.**
*Aëdes* (*Skusea*) *pembaensis*, characters of, **341.**
*Aëdes* (*Dendroskusea*) *periskeletus*, characters of, **341.**
*Aëdes* (*Aëdimorphus*) *phyllolabis*, sp. n., from Belgian Congo, **324.**
*Aëdes* (*Dendroskusea*) *punctipes*, characters of, **341.**
*Aëdes* (*Dendroskusea*) *punctissimus*, characters of, **341.**
*Aëdes* (*Banksinella*) *punctocostalis*, early stages of, **63.**
*Aëdes* (*Dendroskusea*) *reginae*, characters of, **341.**
*Aëdes rusticus*, instar records of, **195–198.**
*Aëdes similis*, **342.**
*Aëdes* (*Cancraëdes*) *simplex*, characters of, **342.**
*Aëdes* (*Aëdimorphus*) *tarsalis*, **324**; breeding-places of, in W. Africa, **60**; early stages of, **67**; *Neopecomyia uniannulata*, possibly not a synonym of, **325.**
*Aëdes* (*Geoskusea*) *tonsus*, **316**; characters of, **341.**
*Aëdes* (*Chaetocruiomyia*) *tulliae*, sp. n., from Queensland, **275.**
*Aëdes umbrosus*, **316.**
*Aëdes* (*Neopecomyia*) *uniannulata*, doubtful identity of, **325.**
*Aëdes* (*Stegomyia*) *variegatus*, in Fiji, **338**; in Solomon Is., **305.**
*Aëdes variegatus* var. *hebrideus*, **338.**
*Aëdes variegatus* var. *pseudoscutellaris*, **338.**
*Aëdes variegatus* var. *tongae*, **304.**
*Aëdes* (*Aëdimorphus*) *vexans*, **314.**
*Aëdes* (*Chaetocruiomyia*) *wattensis*, sp. n., from Queensland, **275.**
*Aëdimorphus*, a subgenus of *Aëdes*, *q.v.*
*Aëdomyia*, key to species of, **326**; characters of squama of, **343.**
*Aëdomyia africana*, *A. furfurea* distinct from, **325.**
*Aëdomyia furfurea*, a distinct species, **325.**
*Aëdomyia squamipennis*, **326.**
*Aëdomyia venustipes*, characters of, **325.**
*aegeon*, *Golofa.*
*aegyptiaca*, *Cryptobremia.*
*aenea*, *Anomala.*
Aeroplanes, survey of citrus plantations by, **431.**
*Afreutreta*, characters and scope of, **395–396.**
*Afreutreta bipunctata*, **396, 397.**
*Afreutreta biseriata*, **396.**
*Afreutreta discoidalis*, **396, 397.**
*Afreutreta frauenfeldi*, **396.**
*Afreutreta millepunctata*, **396.**
*Afreutreta millepunctata* var. *limbatella*, **396.**
*afreutretae*, *Opius.*
Africa, new Anophelines from, **322**; Bombyliid parasites of *Glossina* in, **151–164**; Chalcidoid parasites in, **256, 414, 420, 421.**
Africa, South, new Braconid parasites from, **105, 114**; species of *Nysius* from, **267–269**; new Trypetids from, **391–400.**
Africa, West, mosquitos from, **59–68, 327.**
*africana*, *Aëdomyia*; *Diaspis.*
*africanus*, *Elasmus*; *Zeugmatothripoides.*
*agamemnonis*, *Apanteles* (see *A. papilionis*).
Agathi (see *Sesbania*).
*Agonoscelis puberula*, **209.**
*Agonoscelis versicolor*, bionomics and control of, on *Sorghum* in Sudan, **209–224.**
*Agropyron repens*, food-plant of *Lema melanopa* in Britain, **9.**
*Agrotis ypsilon*, **101.**
*Alabama argillacea*, control of, on cotton in Peru, **226.**
*alatus*, *Aspidiotus.*
*alba*, *Lepidosaphes bicornis.*
*albescens*, *Uranotaenia.*
*albidus*, *Nysius.*
*albilabris*, *Aëdes* (*Finlaya*).
*albinervis*, *Culex.*
*albipes*, *Psyche.*
*albocephalus*, *Anopheles.*
*albolineatus*, *Aëdes* (*Stegomyia*).
*albomaculatus*, *Elasmus.*
*albopictus*, *Elasmus.*
*alboscutellata*, *Nippia.*
*albus*, *Aspidiotus* (*Chrysomphalus*) *fodiens.*
*Aleurobius*, **119.**
Alfalfa Weevil (see *Hypera variabilis*).
Algae, relation of mosquito larvae to, **53–57.**
*allophylli*, *Chionaspis* (*Poliaspis*) *kiggelariae.*
*Allophyllus*, new Coccids on, in S. Rhodesia, **371, 374.**
*Aloe*, Coccid on, in S. Rhodesia, **365.**
*Alpinia*, new Hispid on, in Solomon Is., **239.**
*alpiniae*, *Promecotheca.*
*Alstonia*, Coccid on, in Australia, **33.**
*Alysia manducator*, **426.**
*amabilis*, *Eublemma.*
*amanda*, *Ocnerogyia.*
*amaniensis*, *Chionaspis.*

*amazuluana, Perilampsis.*
*amesi, Aëdes.*
*Amorphota ephestiae* (see *Nemeritis canescens*).
*Anacridium moestum melanorhodon,* in Sudan, **99.**
*Anaphothrips citricinctus,* food-plants of, in India, **79.**
*Anaphothrips oligochaetus,* food-plants of, in India, **79.**
*Anaphothrips ramakrishnae,* on *Pennisetum typhoideum* in India, **79.**
*Anastatus colemani,* parasite of *Tetroda histeroides* in India, **177.**
*Anastrepha fraterculus,* food-plants of, in Peru, **229.**
*andreae, Dysdercus.*
*Anisostena fasciata,* sp. n., from Brazil, **87.**
*annulata, Theobaldia.*
*annulirostris, Culex.*
*Anomala aenea,* bionomics and control of, on vines in Ukraine, **95.**
*anomalus, Brachyurothrips.*
*Anomis texana,* control of, on cotton in Peru, **226.**
*Anopheles albocephalus,* **325.**
*Anopheles bifurcatus,* instar records of, **195–198.**
*Anopheles brunnipes,* subgeneric position of, **321.**
*Anopheles gigas* var. *baileyi,* n., from Tibet and W. China, **323.**
*Anopheles gigas* var. *refutans,* description of, **323.**
*Anopheles gigas* var. *simlensis,* **323.**
*Anopheles hyrcanus,* local races of, **323, 324.**
*Anopheles hyrcanus* var. *mesopotamiae,* distribution of, **324.**
*Anopheles hyrcanus* var. *nigerrimus* (*peditaeniatus*), distribution of, **324.**
*Anopheles hyrcanus* var. *pictus,* distribution of, **324.**
*Anopheles hyrcanus* var. *pseudopictus,* distribution of, **324.**
*Anopheles hyrcanus* var. *sinensis,* distribution of, **324.**
*Anopheles lindesaii* var. *cameronensis,* n., from Malaya, **323.**
*Anopheles lindesaii* var. *japonicus* (*pleccau*), **323.**
*Anopheles lindesaii* var. *nilgiricus,* **323.**
*Anopheles maculatus,* instar records of, **195–198.**
*Anopheles maculipalpis,* **321.**
*Anopheles maculipennis,* instar records of, **195–198.**
*Anopheles marshalli,* **321.**
*Anopheles minutus,* **324.**
*Anopheles peditaeniatus* (see *A. hyrcanus* var. *nigerrimus*).
*Anopheles pleccau* (see *A. lindesaii* var. *japonicus*).
*Anopheles plumbeus,* breeding in tree-holes in Britain, **47, 49, 54;** food of larva of, **56.**
*Anopheles pretoriensis,* **321.**
*Anopheles punctulatus,* in Solomon Is., **304.**
*Anopheles rufipes,* description of, **321.**
*Anopheles rufipes* var. *ingrami,* n., from W. Africa, **322.**
*Anopheles smithi,* breeding-places of, in W. Africa, **60.**
*Anopheles theileri,* description of, **322.**
*Anopheles theileri* var. *brohieri,* n., from Gold Coast, **322.**
*Anopheles theileri* var. *hancocki,* n., from Africa, **322.**
*Anopheles theileri* var. *seydeli,* n., from Belgian Congo, **322.**
*Anopheles watsoni,* **322.**
*Anoplitis canavaliae,* sp. n., on *Canavalia ensiformis* in Brazil, **89.**
*Anoxia orientalis,* bionomics and control of, on vines in Ukraine, **95.**
*Anoxia pilosa,* bionomics and control of, on vines in Ukraine, **95.**
*Anoxia villosa,* bionomics and control of, on vines in Ukraine, **95.**
*antennatus, Dysdercus.*
*Anthaxia congregata,* parasite of, in Sudan, **107.**
*anthaxiae, Hecabalodes.*
*anthelae, Apanteles.*
*anthonomi, Microdontomerus.*
*Anthonomus grandis,* parasite of, in U.S.A., **255.**
*Anthonomus vestitus,* on cotton in Peru, **226.**
*Anthribus,* parasite of, in U.S.A., **255.**
*anticles, Elasmus.*
*antipoda, Apanteles* (see *A. ruficrus*).
*Anuraphis cardui,* Cecidomyiids predacious on, **436, 437.**
*Anuraphis kochi,* Cecidomyiid predacious on, in France, **434.**
*Anuraphis malifoliae* (see *A. roseus*).
*Anuraphis padi,* Cecidomyiid predacious on, in Britain, **437.**
*Anuraphis roseus,* Cecidomyiids predacious on, **434, 438, 440.**
*Aonidiella* (see *Aspidiotus*).
*aonidum, Chrysomphalus* (see *Aspidiotus ficus*).
*Apanteles agamemnonis* (see *A. papilionis*).
*Apanteles anthelae,* **451.**
*Apanteles antipoda* (see *A. ruficrus*).
*Apanteles aristolochiae,* **108.**
*Apanteles australiensis,* **110.**
*Apanteles badgleyi,* **447.**
*Apanteles belippae,* **447.**

*Apanteles belliger*, sp. n., parasite of *Cirphis unipuncta* in Mauritius, **107.**
*Apanteles calycinae*, **111, 112.**
*Apanteles cheesmanae*, **451.**
*Apanteles deliadis*, **110.**
*Apanteles effrenus*, **451.**
*Apanteles eucosmae*, sp. n., parasite of *Diacrisia mundata* in Tropical Africa, **445, 447.**
*Apanteles flavipes*, parasite of *Phragmatiphila truncata* in Australia, **108**; synonymy of, **108.**
*Apanteles fuscinervis*, **447.**
*Apanteles grandiculus*, sp. n., from India, **110.**
*Apanteles hypsipylae*, **451.**
*Apanteles importunus*, parasite of *Nephopteryx rhodobasalis* in India, **111.**
*Apanteles jujubae*, sp. n., from India, **450.**
*Apanteles leptoura*, parasite of *Terastia meticulosalis* in India, **111.**
*Apanteles malevolus*, sp. n., parasite of *Hyblaea puera* in India, **109.**
*Apanteles mendosae*, sp. n., parasite of *Dasychira mendosa* in F.M.S., **113.**
*Apanteles mlanje*, sp. n., from Nyasaland, **449.**
*Apanteles neavei*, sp. n., from Nyasaland, **447.**
*Apanteles nonagriae* (see *A. flavipes*).
*Apanteles pallidocinctus*, **107.**
*Apanteles paludicolae*, parasite of *Sphenarches caffer* in Sudan, **109.**
*Apanteles papilionis*, in Assam, **107**; synonymy of, **107.**
*Apanteles pistrinariae*, sp. n., parasite of *Mylothris chloris* in S. Rhodesia, **443.**
*Apanteles pistrinariae nyasaensis*, subsp. n., from Nyasaland, **445.**
*Apanteles prodeniae*, **113.**
*Apanteles radiantis*, sp. n., parasite of *Euxoa radians* in Australia, **110.**
*Apanteles rubecula*, **451.**
*Apanteles ruficrus*, **110**; hosts of, **108**; synonymy of, **108.**
*Apanteles rufiventris*, **451.**
*Apanteles sagax*, sp. n., parasite of *Sylepta derogata* in E. Africa, **112.**
*Apanteles syleptae*, **112.**
*Apanteles taprobanae*, **109, 110**; parasite of *Stauropus* in India, **109.**
*Apanteles tavagamae*, parasite of *Nephantis serinopa* in India, **113.**
*Apanteles tiracholae*, **451.**
*Aphanus novitius*, transferred from *Nysius*, **267** (note).
*aphidimyza, Phaenobremia.*
*aphidisuga, Phaenobremia.*
*Aphidius*, **459**; parasite of *Guerciobremia cucullata* in Italy, **439.**
*aphidivora, Cecidomyia ; Phaenobremia.*
*Aphidoletes*, predacious on Aphids, **434, 435.**
*Aphidoletes abietis*, predacious on Aphid in France, **434.**
*Aphidoletes flavida*, **440.**
*Aphidoletes marginata*, **440.**
*Aphidoletes recurvata*, **440.**
Aphids, Cecidomyiids as enemies of, **433–442.**
*Aphis asclepiadis* (see *A. nerii*).
*Aphis avenae*, Cecidomyiid predacious on, **437.**
*Aphis gossypii*, on cotton in Peru, **227**; Cecidomyiids predacious on, **434–437.**
*Aphis helianthi*, Cecidomyiid predacious on, **437.**
*Aphis maidis*, Cecidomyiid predacious on, **437.**
*Aphis nerii*, Cecidomyiid predacious on, **437.**
*Aphis pomi*, Cecidomyiids predacious on, **435, 438, 439.**
*Aphis pseudobrassicae*, Cecidomyiid predacious on, in U.S.A., **434.**
*Aphis sacchari*, Cecidomyiid predacious on, in Hawaii, **438.**
*Aphis symphyti*, Cecidomyiid predacious on, in Italy, **439.**
*Aphis urticaria*, Cecidomyiid predacious on, in France, **438.**
*aphisuga, Trilobia.*
*apicalis, Odoniella.*
*appendigaster, Eurytoma.*
Apple, food-plant of *Anastrepha fraterculatus* in Peru, **229.**
*argenteus, Aëdes.*
*argentifrons, Thyridanthrax.*
Argentina, parasite of *Diatraea saccharalis* in, **200.**
*argillacea, Alabama.*
*argyritarsis, Uranotaenia.*
*aristolochiae, Apanteles.*
*armigera, Heliothis.*
*Armigeres*, characters of squama of, **343.**
*Armigeres malayi* var. *breinli*, in Solomon Is., **305**; larva of, **314.**
*Arrhenothrips ramakrishnae*, on *Mimusops elengi* in India, **78.**
Arrowroot, thrips on, in India, **79.**
*Arthrocnodax farinicola*, sp. n., in flour in Naples, **121.**
Artichoke, Aphid on, in Italy, **439.**
*articulatus, Aspidiotus* (*Pseudaonidia, Selenaspidus*).
*Artocarpus integrifolia* (Jak), Pentatomid on, in India, **174.**
*arundinis, Hyalopterus.*
*asclepiadens, Dacus* (see *D. brevistriga*).
*asclepiadis, Aphis* (see *A. nerii*).
*ashmeadi, Elasmus.*
*Aspidiotus alatus*, **24.**

*Aspidiotus aonidum* ( see *A. ficus*).
*Aspidiotus* (*Selenaspidus*) *articulatus*, on orange in Peru, **229**; food-plants of, in S. Rhodesia, **356**.
*Aspidiotus* (*Aonidiella*) *aurantii*, food-plants of, in Australia, **25**.
*Aspidiotus* (*Hemiberlesia*) *camelliae*, **22, 354**; on *Acacia mollissima* in S. Rhodesia, **352**.
*Aspidiotus combreti* var. *zizyphi*, n., food-plants of, in S. Rhodesia, **346**.
*Aspidiotus* (*Morganella*) *conspicua*, food-plants of, in S. Rhodesia, **356**; correct subgenus for, **356**.
*Aspidiotus delicatulus*, sp. n., on *Melaleuca leucadendron* in Australia, **23**.
*Aspidiotus* (*Chrysomphalus*) *dictyospermi*, on orange in S. Rhodesia, **356**.
*Aspidiotus* (*Neoleonardia*) *extensus*, **24**.
*Aspidiotus* (*Chrysomphalus*) *ficus* (*aonidum*), measures against on *Citrus*, in Egypt & Palestine, **44, 431**.
*Aspidiotus* (*Chrysomphalus*) *fodiens* var. *albus*, n., from Australia, **26**.
*Aspidiotus furcillae*, on *Berlinia globiflora* in S. Rhodesia, **347**.
*Aspidiotus gidgei*, on *Acacia stenophylla* in Australia, **21**.
*Aspidiotus* (*Aonidiella*) *gowdeyi*, on *Chrysophyllum argyrophyllum* in S. Rhodesia, **356**.
*Aspidiotus hederae*, food-plants of, in Australia, **23**.
*Aspidiotus* (*Morganella*) *longispina*, **356**.
*Aspidiotus loranthi*, sp. n., on *Loranthus pendulus* in Australia, **21**.
*Aspidiotus mashonae*, sp. n., on *Combretum* in S. Rhodesia, **347**.
*Aspidiotus* (*Diaspidiotus*) *mazoeensis*, sp. n., from S. Rhodesia, **351**.
*Aspidiotus* (*Aonidiella*) *monotes*, sp. n., on *Monotes glaber* in S.Rhodesia, **357**.
*Aspidiotus msolonus*, sp. n., on *Pseudolachnostylis* in S. Rhodesia, **348**.
*Aspidiotus* (*Diaspidiotus*) *pectinatus*, **348, 352**.
*Aspidiotus* (*Hemiberlesia*) *rhodesiensis* var. *umtalii*, n., on *Brachystegia* in S. Rhodesia, **352**.
*Aspidiotus* (*Chrysomphalus*) *rossi*, **26**; food-plants of, in Australia, **27**; food-plants of, in S. Rhodesia, **356**.
*Aspidiotus* (*Aonidiella*) *subrossi*, sp. n., on *Acacia rubra* in Australia, **26**.
*Aspidiotus subrubescens*, on *Loranthus pendulus* in Australia, **25**.
*Aspidiotus tectonae*, **354, 356**.
*Aspidiotus tuberculatus*, sp. n., on *Melaleuca* in Australia, **24**.
*Aspidiotus vernoniae*, sp. n., on *Vernonia podocoma* in S. Rhodesia, **350**.
*Aspidiotus* (*Hemiberlesia*) *zizyphi*, sp. n., food-plants of, in S. Rhodesia, **353**.
*Aspidiotus* (*Hemiberlesia*) *zizyphi* var. *securidacae*, n., food-plants of, in S. Rhodesia, **355**.
*Aspidistra*, Coccid on, in Australia, **23**.
*atlanis*, *Melanoplus mexicanus*.
*atripes*, *Rachionotomyia*.
*Atta sexdens*, food-plants of, in Peru, **230**.
*atymnius*, *Castnia*.
*Aulatopria tucumana*, parasite of *Paratheresia signifera* in Argentina, **200**.
*Aulostyrax nuciferae*, gen. et sp. n., on coconuts in Solomon Is., **235**.
*aurantia*, *Pardomyia*.
*aurantii*, *Aspidiotus* (*Aonidiella*) ; *Toxoptera*.
*auratilis*, *Chionaspis*.
Australia, Braconids from, **108, 110**; notes on Coccidae of, **15–37**; notes on mosquitos from, **271–277**; natural enemies of *Plodia interpunctella* and *Silvanus surinamensis* in, **425–430**.
*australiensis*, *Apanteles*.
Austria, Cecidomyiid predacious on Aphid in, **437**.
*avenae*, *Aphis*.
Avocado, pests of, in Peru, **229, 230**.
*Ayyaria chaetophora*, on *Vigna catjang* in India, **79**.

## B.

*badgleyi*, *Apanteles*.
*baileyi*, *Anopheles gigas*.
*Balanites*, Coccid on, in S. Rhodesia, **370**.
*balsamines*, *Macrosiphoniella*.
Bamboo, relation of *Glossina morsitans* to, **289**.
Banana, thrips on, in India, **79**; bionomics of *Castniomera humboldti* on, in Colombia, **187–192**.
*Banksia serrata*, new Coccid on, in Australia, **31**.
*Banksinella*, a subgenus of *Aëdes*, *q.v.*
Barley, food-plant of *Lema melanopa* in Britain, **9**.
*basalis*, *Microplitis* ; *Phaenobremia*.
*Bauhinia* spp., Coccid on, in S. Rhodesia, **356**; Arctiid on, in Uganda, **447**; relation of *Glossina morsitans* to, **289**.
*beckii*, *Lepidosaphes*.
Beech (see *Fagus sylvaticus*).
*belippae*, *Apanteles*.
*belliger*, *Apanteles*.
*bellus*, *Elasmus*.

*benefactrix, Mutilla.*
*beneficus, Thyridanthrax.*
*Berkheya magaliesmontana,* new Trypetid on, in S. Africa, **399.**
*Berlesaspis spinifera,* on *Acacia* in Australia, **36.**
*Berlesaspis spinifera* var. *major,* doubtful validity of, **37.**
*Berlinia,* relation of *Glossina morsitans* to, **289.**
*Berlinia globifera,* Coccid on, in S. Rhodesia, **347.**
*bezzii, Guerciobremia.*
*bicornis, Lepidosaphes.*
*biformis, Furcaspis.*
*bifurcatus, Anopheles.*
*bimaculata, Uranotaenia.*
*bimaculatus, Microplitis.*
*binervis, Bregmatothrips.*
*binotatus, Nysius.*
*biplaga, Earias.*
*bipunctata, Afreutreta.*
*bipunctifer, Schoenobius* (see *S. incertellus*).
*biseriata, Afreutreta.*
*bispinoides, Hoplandrothrips.*
*bispinosus, Hoplandrothrips; Sericothripoides* (*Dendrothrips*).
*Bistrispinaria,* **393.**
*bitaeniorhynchus, Culex.*
*bondari, Chalepus.*
*borealis, Phaenobremia.*
Borneo, *Elasmus fumipennis* in, **417.**
Box Elder Aphid (see *Chaitophorus negundinis*).
*Brachymeria fijiensis,* sp. n., parasite of *Platyedra gossypiella* in Fiji, **255.**
*Brachymeria obscurata,* parasite of *Platyedra gossypiella* in Hawaii, **256;** parasite of *Sylepta derogata* in Philippines, **256.**
*Brachymeria olethrius,* parasite of *Platyedra gossypiella* in Africa, **256.**
*Brachymeria* (*Chalcis*) *varipes,* parasite of *Glossina morsitans* in Gold Coast, **283;** in S. Rhodesia, **286.**
*Brachystegia,* new Coccid on, in S. Rhodesia, **353;** relation of *Glossina morsitans* to, **289.**
*Brachyurothrips,* characters of, **69.**
*Brachyurothrips anomalus,* **69, 70.**
*Brachyurothrips hargreavesi,* sp. n., on *Acalypha* in Sierra Leone, **70.**
*Brachyurothrips indicus* (see *Selenothrips*).
*braconidis, Eurytoma.*
*brassicae, Brevicoryne.*
Brazil, food-plants of new Hispids in, **86–94;** new weevils on cacao in, **203, 204.**
*Bregmatothrips binervis,* on sugar-cane in India, **79.**
*breinli, Armigeres malayi.*
*Bremia* spp., predacious on Aphids in Russia, **435.**
*brevicornis, Elasmus; Habrobracon.*
*Brevicoryne brassicae,* Cecidomyiid predacious on, in Canada, **437.**
*brevipalpis, Megarhinus; Stylothrips.*
*brevistriga, Dacus* (*Leptoxyda*).
Brinjal (see Egg-plant).
British Isles, bionomics and control of *Lema melanopa* in, **5–14;** bionomics of mosquitos breeding in tree-holes in, **45–58;** Cecidomyiids predacious on Aphids in, **433, 434, 437–440.**
*brohieri, Anopheles theileri.*
*Brontispa,* **85.**
*brucei, Trypanosoma.*
*Bruchus,* parasite of, in U.S.A., **255.**
*brugi, Aëdes* (*Banksinella*).
*brunnipes, Anopheles.*
*bryanti, Parafreutreta.*
*Bryocoropsis cotterelli,* sp. n., on cacao in Fernando Po, **253.**
*Bryocoropsis laticollis,* **254.**
*buxtoni, Culex* (*Lophoceratomyia*) *hilli.*

## C.

Cabbage, thrips on, in India, **78.**
Cacao, new weevils on, **201, 203, 204;** new Capsid on, in Fernando Po, **254;** *Stirastoma depressum* on, in Trinidad, **205.**
*Cactus,* Coccid on, in Australia, **25.**
*Caesalpinia,* thrips on, on India, **79.**
*Caesalpinia pulcherrima, Acrocercops* on, in Philippines, **414.**
*caffer, Sphenarches.*
*Calandra,* growth of larva of, **246.**
*caledonica, Rachionotomyia.*
*caliginea, Glossina.*
*Calliphora,* **426.**
*Callipterus trifolii* (see *Therioaphis ononidis*).
*Callitris,* new Coccid on, in Australia, **20.**
*callitris, Poliaspis.*
*calycinae, Apanteles.*
*Calycothrix tetragona,* new Coccid on, in Australia, **34.**
*Camaromyia conferta* (see *Parafreutreta*).
*camelliae, Aspidiotus* (*Hemiberlesia*).
*cameronensis, Anopheles lindesaii.*
*camphorae, Dermatodes.*
Canada, Cecidomyiids predacious on Aphids in, **437, 438, 440.**
Canary Grass (see *Phalaris canariensis*).
*Canavalia ensiformis* (Sword Bean), thrips on, in India, **79;** new Hispids on, in Brazil, **86, 90.**

*canavaliae, Anoplitis.*
*Cancraëdes*, a new subgenus of *Aëdes* (*q.v.*), **342.**
*cancricomes, Aëdes* (*Cancraëdes*).
*canescens, Nemeritis.*
*Canthium lanciflorum*, Coccids on, in S. Rhodesia, **355, 356.**
*capensis, Chionaspis.*
*capitata, Ceratitis.*
*Capitophorus ribis*, Cecidomyiids predacious on, in Russia & England, **435.**
*Capitophorus rosarum*, Cecidomyiid predacious on, in France, **434.**
*Capparis*, Coccid on, in Italian Somaliland, **346.**
*Carabus*, **404, 405, 406.**
*cardui, Anuraphis; Phaenobremia.*
*Carissa arduina*, new Coccid on, in S. Rhodesia, **363.**
*carmenti, Aëdes* (*A.*).
*carnifex, Phaenobremia.*
*Carpophthoromyia*, **393.**
*Carpophthoromyia dimidiata*, **393, 394.**
*Carpophthoromyia superba*, **393.**
cashew, thrips on, in India, **78.**
*Caspius, Aëdes.*
*Cassia tettensis*, new Coccid on, in S. Rhodesia, **355.**
*castanea, Diparopsis.*
*castaneiceps, Spatulicraspeda.*
*Castnia acraeoides*, **192.**
*Castnia atymnius*, **192.**
*Castnia daedalus*, on coconut in Br. Guiana, **192**; on banana in Dutch Guiana, **192.**
*Castnia drucei*, **192.**
*Castnia eudesmia*, **192.**
*Castnia humboldti* var. *rufolimba* (see *C. drucei*).
*Castnia licoides*, **190**; control of, on on sugar-cane in Br. Guiana, **192.**
*Castnia therapon*, **192.**
*Castniomera humboldti*, bionomics of, on banana in Colombia, **187–192.**
Castor, thrips on, in India, **78.**
Castor Oil, in formula against *Aspidiotus ficus*, **44**; experiments with, against *Platyedra gossypiella*, **42.**
*Casuarina*, new Coccid on, in Australia, **30.**
*casuarinae, Lepidosaphes.*
*cautella, Ephestia.*
*Cavariella pastinaceae*, Cecidomyiid predacious on, **438.**
Cecidomyiids, as enemies of Aphids, **433–440.**
*Cecidomyia aphidivora*, possibly predacious on Aphid in U.S.A., **440.**
Celebes, new Hispid on coconut in, **83.**
*Cephalolia histrio*, **89.**
*Cephalolia saccharina*, sp. n., on sugar-cane in Brazil, **88.**
*Cephalonomia*, parasite of *Silvanus surinamensis*, **428**; habits and life-history of, in Australia, **429–430.**
*cerasi, Myzus.*
*Ceratitis*, **394.**
*Ceratitis capitata* (Mediterranean Fruit-fly), inter-relation of parasites of, **142, 146–148.**
Ceylon, Braconid parasite of *Natada nararia* in, **107**; *Elasmus* spp. in, **412, 416, 418.**
*ceylonica, Fornicia.*
*ceylonicus, Elasmus; Haplothrips.*
*chaetachmae, Chionaspis.*
*Chaetocruiomyia* (see *Aëdes*).
*chaetophora, Ayyavia.*
*Chaitophorus negundinis*, Cecidomyiids predacious on, in U.S.A., **435, 438.**
*Chalcis varipes* (see *Brachymeria*).
*Chalepus bondari*, sp. n., from Brazil, **92.**
*Chara*, **271.**
*Charops*, parasite of *Acraea acerata* in Uganda, **104.**
*chavicae, Gynaikothrips.*
*cheesmanae, Apanteles.*
*Chelyophora*, **393.**
*Cheyletus*, **119.**
Chillie, thrips on, in India, **78, 79.**
China, new Braconid from, **206**; new mosquito from, **323.**
*Chionaspis amaniensis*, **373, 374.**
*Chionaspis auratilis*, **373, 374.**
*Chionaspis capensis*, **373.**
*Chionaspis chaetachmae*, on *Phoenix dactylifera* in S. Rhodesia, **364.**
*Chionaspis chaetachmae* var. *imbricata*, n., from S. Rhodesia, **364.**
*Chionaspis* (*Pinnaspis*) *combreti*, **368, 369.**
*Chionaspis* (*Pinnaspis*) *communis* var. *diospyros*, n., on *Diospyros* in S. Rhodesia, **365.**
*Chionaspis communis* var. *monotes*, **366.**
*Chionaspis* (*Dinaspis*) *dentilobis*, on mistletoe in S. Rhodesia, **371.**
*Chionaspis* (*Phenacaspis*) *dilatata*, on mango in Natal, **345.**
*Chionaspis* (*Dinaspis*) *distincta*, on *Protea* in S. Rhodesia, **345.**
*Chionaspis distorta*, **346.**
*Chionaspis* (*Dinaspis*) *dura*, in Uganda, **346.**
*Chionaspis exalbida*, on *Aloe* in S. Rhodesia, **365.**
*Chionaspis* (*Pinnaspis*) *excisa*, sp. n., on *Combretum* in S. Rhodesia, **366.**
*Chionaspis fici*, on *Terminalia* spp. in S. Rhodesia, **365.**
*Chionaspis* (*Phenacaspis*) *formosa*, on *Eucalyptus rostrata* in Australia, **17.**
*Chionaspis* (*Dinaspis*) *gibber*, sp. n., from S. Rhodesia, **372.**

*Chionaspis* (*Poliaspis*) *higgelariae* var. *allophylli*, n., on *Allophyllus* in S. Rhodesia, **374.**
*Chionaspis* (*Dinaspis*) *lounsburyi*, on *Gymnosporia* in S. Rhodesia, **373.**
*Chionaspis* (*Pinnaspis*) *melaleucae*, sp. n., on *Melaleuca leucadendron* in Queensland, **15.**
*Chionaspis* (*Pinnaspis*) *minima*, **16.**
*Chionaspis* (*Phenacaspis*) *natalensis* (see *C. dilatata*).
*Chionaspis* (*Dinaspis*) *pittospori*, sp. n., food-plants of, in S. Rhodesia, **373.**
*Chionaspis proteae* (see *C. distincta*).
*Chionaspis* (*Dinaspis*) *reticulata*, on *Capparis* in Italian Somaliland, **346.**
*Chionaspis rotundiloba*, sp. n., on *Eucalyptus* in Queensland, **16.**
*Chionaspis stanotophri*, on *Cymbopogon giganteus* in S. Rhodesia, **365.**
*Chionaspis striata*, **20.**
*Chionaspis* (*Phenacaspis*) *subvisci*, sp. n., on *Elaeodendron capense* in S. Rhodesia, **369.**
*Chionaspis tenuidisculus*, **373, 374.**
*Chionaspis* (*Pinnaspis*) *tuberculata*, sp. n., on *Uapaca kirkiana* in S. Rhodesia, **368.**
*Chionaspis uapacae* (see *C. dura*).
*Chionaspis* (*Phenacaspis*) *visci*, on *Balanites* in S. Rhodesia, **370.**
*Chionaspis* (*Phenacaspis*) *visci* var. *umtalii*, n., on *Allophyllus* in S. Rhodesia, **370.**
*chitinosa, Lepidosaphes.*
*chitonosa, Lepidosaphes* (see *L. froggatti*).
*chloris, Mylothris.*
Cholam (see *Sorghum*).
*Chrysanthemum*, thrips on, in India, **79**; Aphid on, in Italy, **439.**
*chrysippus, Danais.*
*chrysogaster, Eretmopodites.*
*Chrysomphalus* (see *Aspidiotus*).
*chrysomphalus, Dacus.*
*Chrysophyllum argyrophyllum*, Coccid on, in S. Rhodesia, **356**; relation of *Glossina morsitans* to, **289.**
*Cicindela*, **403.**
*cineraria, Diplosis.*
*cinerellus, Culex.*
*Cinnamomum camphora*, new weevil on, in Java, **202.**
*Cirphis loreyi*, Braconid parasite of, in Sudan, **108.**
*Cirphis unipuncta*, new Braconid parasite of, in Mauritius, **108.**
*Cirsium arvense*, Aphids on, **436.**
*citricinctus, Anaphothrips.*
*Citrus*, spraying against scale-insects on, in Egypt, **44**; thrips on, in India, **79**; *Atta sexdens* attacking, in Peru, **230**; aerial survey of, in Palestine, **431.**
*Citrus aurantium* (see Orange).
*cladii, Furcaspis* (*Paraonidiella*).
*claripennis, Elasmus.*
*clavicornis, Nysius* (see *Rhypodes zealandicus*).
*Clinotaenia*, **393.**
*coarctata, Pourretia.*
Coccidae, notes on Australian, **15–37**; of S. Rhodesia, **345–376.**
Cocksfoot (see *Dactylis glomerata*).
Coconut (*Cocos nucifera*), *Castnia daedalus* on, in Br. Guiana, **192**; thrips on, in India, **79**; pests of, in Malaya, **74, 409**; new Hispids on, in Celebes, Moluccas and Solomon Is., **81–85, 237.**
*cocosivora, Oliarus.*
*Coelaenomenodera*, **233.**
*coffeae, Hoplandrothrips.*
*coffearia, Homona.*
Coffee, new thrips on, in Tanganyika, **76.**
*colemani, Anastatus*; *Elasmus* (see *E. claripennis*).
*Colocasia*, thrips on, in India, **78.**
Colombia, bionomics of *Castniomera humboldti* on banana in, **187–192.**
*combreti, Aspidiotus*; *Chionaspis.*
*Combretum*, new Coccids on, in S. Rhodesia, **348, 368**; relation of *Glossina morsitans* to, **289, 290.**
*communis, Laccifer* (*Lakshadia*).
*concinnatus, Mesochorus.*
*conferta, Parafreutreta.*
Congo, Belgian, new Braconid parasite from, **446**; new *Glossina* from, **1**; mosquitos from, **324, 327, 331, 333.**
*congolense, Trypanosoma.*
*congregata, Anthaxia.*
*Conotrachelus curvicostatus*, sp. n., on cacao in Brazil & Fr. Guiana, **203.**
*conspicua, Aspidiotus* (*Morganella*).
*constricta, Hemiberlesia fissidens* (see *Aspidiotus gowdeyi*).
*contigua, Diplosis.*
*contorta, Lepidosaphes.*
*costatus, Dermatodes.*
*cotterelli, Bryocoropsis.*
Cotton, *Euxoa radians* on, in Australia, **110**; pests of, in Egypt, **41–43, 78, 79**; *Mylloceras maculosus* on, in India, **208**; notes on *Dysdercus* spp. on, in Nigeria, **38**; pests of, in Peru, **226–228**; Aphid on, in Russia, **435**; thrips on, in Sudan, **73.**
Cotton-stainers (see *Dysdercus*).
Cow-pea (see *Vigna catjang*).
*crassifemur, Eulimneria.*
*cretica, Sesamia.*
*Crotalaria juncea* (Sunn Hemp), thrips on, in India, **79.**

*Croton*, thrips on, in India, **78.**
*Crotophaga ani*, predacious on *Castnia licoides* in Br. Guiana, **192.**
*cruentatus, Rhipiphorothrips.*
*Cryptobremia aegyptiaca*, predacious on Aphid in Egypt, **434.**
*cucullata, Guerciobremia.*
*cucumeris, Phaenobremia.*
*Cucumis sativa*, Aphid on, in Astrakhan, **436.**
*Culex*, characters of squama of, **343.**
*Culex albinervis*, sp. n., from Fiji, **338**; breeding-places of, **339–340.**
*Culex annulirostris*, in Fiji, **340**; breeding-places of, in Solomon Is., **307.**
*Culex bitaeniorhynchus*, **339.**
*Culex cinerellus*, breeding-places of, in Nigeria, **327.**
*Culex decens*, breeding-places of, in W. Africa, **60.**
*Culex fatigans*, **340**; breeding-places of, in Solomon Is., **307.**
*Culex* (*Lophoceratomyia*) *fraudatrix* var. *solomonis*, n., from Solomon Is., **308, 316.**
*Culex fumipennis*, **197, 198.**
*Culex grahami*, **327, 334.**
*Culex guiarti*, **334.**
*Culex hilli*, **316.**
*Culex* (*Lophoceratomyia*) *hilli* var. *buxtoni*, in Solomon Is., **308.**
*Culex ingrami*, **327.**
*Culex mimeticus*, **323.**
*Culex moucheti*, breeding-places of, in Belgian Congo, **333**; early stages of, **334–337.**
*Culex* (*Culiciomyia*) *papuensis*, in Solomon Is., **308.**
*Culex philipi*, sp. n., breeding-places of, in Nigeria, **327.**
*Culex pipiens*, instar records of, **195–198.**
*Culex pruina*, **327.**
*Culex schwetzi*, sp. n., from Belgian Congo, **326.**
*Culex sitiens*, in Fiji, **340**; in Solomon Is., **307.**
*Culicella morsitans*, instar records of, **195–198.**
*Culiciomyia papuensis* (see *Culex*).
Cumbu (see *Pennisetum typhoideum*).
*cumingi, Promecotheca.*
*curtipes, Aëdes* (*Cancraëdes*).
*curvicostatus, Conotrachelus.*
*cyanella, Lema.*
*Cyanopterus depressi*, **205.**
*Cyanopterus steirastomae*, **205.**
*Cyclopleura*, **411.**
*Cyclopleura fumipennis* (see *Elasmus*).
*Cymbopogon giganteus*, Coccid on, in S. Rhodesia, **365.**
*Cypripedium*, Coccid on, in Australia, **25.**

## D.

*Dactylis glomerata* (Cocksfoot), foodplant of *Lema melanopa* in Britain, **7, 9.**
*Dacus asclepiadens* (see *D. brevistriga*).
*Dacus* (*Leptoxyda*) *brevistriga*, synonymy of, **392.**
*Dacus chrysomphalus*, **391.**
*Dacus fuscatus*, **392.**
*Dacus lounsburyi*, **391.**
*Dacus pectoralis*, **391.**
*Dacus sphaeristicus*, **391.**
*Dacus* (*D.*) *stentor*, sp. n., from S. Africa, **391.**
*daedalus, Castnia.*
*Dahlbergia sissoo*, Noctuid on, in India, **454.**
Daincha (see *Sesbania*).
*Danais chrysippus*, parasite of, in S. Africa, **105.**
*Dasychira mendosa*, new Braconid parasite of, in F.M.S., **113.**
*Dasyneura rhodophaga*, associated with *Phaenobremia rosivora*, **438.**
*Datura*, thrips on, in India, **79.**
*Daviesia* spp., Coccids on, in Australia, **21.**
*decens, Culex.*
*decoratus, Mesochorus.*
*defecta, Lepidosaphes.*
*Deinocerites*, characters of squama of, **343.**
*deliadis, Apanteles.*
*delicatulus, Aspidiotus.*
*Dendroskusea*, a new subgenus of *Aëdes* (*q.v.*), **341.**
*Dendrothrips bispinosus* (see *Sericothripoides*).
*Dendrothrips indicus*, on arrowroot in India, **79.**
Denmark, new Cecidomyiid in stored products in, **120.**
*dentilobis, Chionaspis* (*Dinaspis*).
*depressi, Cyanopterus.*
*depressum, Stirastoma.*
*Dermatodes camphorae*, sp. n., on *Cinnamomum camphora* in Java, **201.**
*Dermatodes costatus*, **202.**
*Dermatodes elevatus*, **202.**
*Dermestes lardarius*, **246.**
*derogata, Sylepta.*
*Desvoidya fusca* (see *Armigeres malayi*).
*detectus, Iridomyrmex.*
*detritus, Aëdes.*
*Diachasma fullawayi*, inter-relation of, with other parasites of *Ceratitis capitata*, **148.**

*Diachasma tryoni*, inter-relation of, with other parasites of *Ceratitis capitata*, **142, 146–148.**
*Diacrisia mundata*, new Braconid parasite of, in Belgian Congo, **446.**
*diademata, Perilampsis.*
*Diaphania* (*Margaronia*) *indica*, Chalcid parasite of, in India, **415.**
*Diaspidiotus* (see *Aspidiotus*).
*Diaspis africana*, **363.**
*Diaspis regularis*, **363, 364.**
*Diaspis subregularis*, sp. n., food-plants of, in S. Rhodesia, **362.**
*Diaspis subregularis* var. *spatulata*, n., on *Sapium mannianum* in S. Rhodesia, **363.**
*Diatraea saccharalis*, parasitised by *Paratheresia signifera* in Argentina, **200;** bionomics and control of, on sugar-cane in Peru, **228–230.**
*diatraeae, Sarcophaga* (see *Paratheresia signifera*).
*dictyospermi, Aspidiotus* (*Chrysomphalus*).
*diemenalis, Lamprosema.*
*dilatata, Chionaspis* (*Phenacaspis*).
*diluta, Disophrys.*
*dimidiata, Carpophthoromyia.*
*Dinaspis* (see *Chionaspis*).
*Dinocampus mylloceri*, sp. n., parasite of *Mylloceras maculosus* in India, **207.**
*Dinocampus rutilus*, **208.**
*Diospyros*, new Coccid on, in S. Rhodesia, **366.**
*Diospyros mespiliformis*, relation of *Glossina morsitans* to, **288.**
*diospyros, Chionaspis* (*Pinnaspis*) *communis.*
*Diparopsis castanea*, hyperparasite of, in Sudan, **257.**
*Diplosis* spp., possibly predacious on Aphids, **440.**
*Dirhinus*, parasite of *Glossina morsitans* in Gold Coast, **283;** in S. Rhodesia, **286.**
*discoidalis, Afreutreta.*
*disjuncta, Microphthalma.*
*Disophrys diluta*, **454, 455.**
*Disophrys exornata*, **455.**
*Disophrys lutea*, **454, 455.**
*Disophrys sissoo*, sp. n., parasite of *Plecoptera reflexa* in India, **453.**
*distalis, Taeniothrips.*
*distigma, Rachionotomyia.*
*distincta, Chionaspis* (*Dinaspis*); *Lepidosaphes.*
*distorta, Chionaspis.*
*Dixomyia elegans* (see *Ficalbia*).
*Dociostaurus maroccanus*, nomenclature of phases of, **264.**
*Dolichos lab-lab*, thrips on, in India, **78, 79.**
*Dolichothrips jeanneli*, **73.**
*Dolichothrips karnyi*, on onion in Tanganyika, **73.**
*Dolichothrips varipes*, on cotton in Br. Sudan, **73;** status of, **73.**
*Dombeya rotundifolia*, new Coccid on, in S. Rhodesia, **360.**
*dombeyae, Howardia.*
*dorsalis, Scirtothrips.*
*Drepanosiphum platanoides*, Cecidomyiid parasitic on, in France & England, **433.**
*drucei, Castnia.*
*dryophila, Thelaxes.*
*dura, Chionaspis* (*Dinaspis*).
Dutch East Indies, thrips on rice in, **77;** new weevil on *Cinnamomum camphora* in, **202;** *Elasmus* spp. in, **413, 418.**
*Dysdercus andreae*, on cotton in W Indies, **227.**
*Dysdercus antennatus*, in Nigeria, **38.**
*Dysdercus intermedius*, not occurring in Nigeria, **38.**
*Dysdercus migratorius*, on cotton in Nigeria, **38.**
*Dysdercus nigrofasciatus*, on cotton in Nigeria, **38.**
*Dysdercus ruficollis*, on cotton in Peru, **227.**
*Dytiscus*, **406.**

## E.

*Earias* spp., Chalcid parasite of, in India, **414.**
*Earias biplaga*, Braconid parasite of, in Uganda, **207.**
*Earias insulana*, parasites of, in Africa, **207, 259, 414.**
*Ecphylus*, **105.**
*edwardsi, Aëdes.*
*effrenus, Apanteles.*
Egg-plant (Brinjal), thrips on, in India, **78, 79.**
Egypt, Cecidomyiid predacious on Aphid in, **434;** measures against *Platyedra gossypiella* in, **41–43;** spraying against scale-insects on citrus in, **44;** thrips on cotton in, **78.**
*Elaeodendron capense*, new Coccid on, in S. Rhodesia, **370.**
*Elasmopalpus lignosellus*, on sugar-cane in Peru, **229.**
*Elasmus*, revision of Asiatic and African species of, **411–423;** key to species of, **422;** list of hosts of, **423.**
*Elasmus africanus*, sp. n., from Nyasaland, **419.**
*Elasmus albomaculatus*, parasite of *Acrocercops* in Philippines, **414.**

*Elasmus albopictus*, in Philippines, **421.**
*Elasmus anticles*, **411**; parasite of *Tinea* sp. in India, **416.**
*Elasmus ashmeadi*, in Philippines, **421.**
*Elasmus bellus*, in Seychelles, **412.**
*Elasmus brevicornis*, hosts of, in India, Java & Malaya, **413.**
*Elasmus ceylonicus*, sp. n., parasite of *Psyche albipes* in Ceylon, **418.**
*Elasmus claripennis*, parasite of *Eublemma amabilis* in India, **418.**
*Elasmus colemani* (see *E. claripennis*).
*Elasmus elegans*, in Philippines, **416.**
*Elasmus eximius*, in Seychelles, **418.**
*Elasmus fumipennis*, in Borneo, **417**; re-description of, **416.**
*Elasmus homonae*, sp. n., parasite of *Homona coffearia* in Ceylon, **415.**
*Elasmus hutsoni*, sp. n., parasite of *Psyche albipes* in Ceylon, **412.**
*Elasmus hyblaeae*, sp. n., parasite of *Hyblaea puera* in India, **414.**
*Elasmus indicus*, hosts of, in India, **415.**
*Elasmus johnstoni*, sp. n., hosts of, in India & Africa, **258, 414.**
*Elasmus lamborni*, sp. n., from Tanganyika, **421.**
*Elasmus lutens*, in Philippines, **421.**
*Elasmus masii*, sp. n., from Seychelles, **415.**
*Elasmus nephantidis*, parasite of *Nephantis serinopa* in India, **415.**
*Elasmus philippinensis*, hosts of, in Philippines & Malaya, **413.**
*Elasmus syleptae*, sp. n., parasite of *Sylepta derogata* in Nyasaland, **420.**
*Elasmus zehntneri*, sp. n., parasite of *Scirpophaga intacta* in Java, **417.**
*elchoensis, Aëdes* (*Chaetocruiomyia*).
*elegans, Elasmus; Ficalbia* (*Dixomyia*); *Gigantothrips*.
*Eleusine* (Ragi), thrips on, in India, **78.**
*elevatus, Dermatodes*.
*Endaphis perfidus*, parasite of Aphid in France & England, **433.**
Entomology, methods of technique applicable to, **165–171.**
Entomology, Economic, status of, in Peru, **225–231.**
*Ephestia cautella*, infesting dried fruit in Australia, **426, 427.**
*ephestiae, Amorphota* (see *Nemeritis canescens*).
*Epidiaspis*, a subgenus of *Aspidiotus*, *q.v.*
*Eretmopodites*, characters of, **328, 343**; keys to early stages of, **328, 329.**
*Eretmopodites chrysogaster*, experimentally transmitting yellow fever, **328**; larva of, **329–330.**
*Eretmopodites chrysogaster* var. *subsimplicipes*, characters of, **329** (note).
*Eretmopodites grahami*, not a variety of *E. chrysogaster*, **330.**
*Eretmopodites inornatus*, early stages of, **331.**
*Eretmopodites leucopus*, in Belgian Congo, **331.**
*Eretmopodites oidipodeios*, early stages of, **330.**
*Eretmopodites quinquevittatus*, larva of, **331.**
*Eretmopodites silvestris*, larva of, **330.**
*Erionota thrax*, Chalcid parasites of, in Java & Philippines, **413.**
*Eriosoma lanigerum*, Cecidomyiid predacious on, in Italy, **434.**
*eriosomiperda, Uncinulella*.
*Erythrina, Terastia meticulosalis* on, in India, **111.**
*Euaresta*, **400.**
*Euarestella*, **400.**
*Eublemma, Elasmus* probably parasitic on, **415, 418.**
*Eublemma amabilis*, Chalcid parasite of, in India, **418.**
*Eucalyptus*, Coccids on, in Queensland, **17, 27, 29, 34.**
*Eucorystes*, **105.**
*eucosmae, Apanteles*.
*eudesmia, Casinia*.
*Eugenia*, thrips on, in India, **78, 79**; relation of *Glossina morsitans* to species of, **289.**
*Eulimneria crassifemur*, **459.**
*Eulimneria* (*Limnerium*) *stellenboschensis*, in S. Africa, **103**; parasite of *Phthorimaea* in Mauritius, **103**; re-description of, **103.**
*Eumycterus saccharidis*, on sugar-cane in Peru, **229.**
*Euonymus*, Coccid on, in Australia, **27.**
*Eupelminus tarsatus*, parasite of *Glossina morsitans* in Nyasaland, **283**; in S. Rhodesia, **286.**
*Eurhynchothrips ordinarius*, on *Sesbania* in India, **79.**
*Eurytoma appendigaster*, characters distinguishing *E. braconidis* from, **257.**
*Eurytoma braconidis*, sp. n., hosts of, in Africa, **256.**
*Eutretosoma*, **395.**
*Euxoa radians*, new Braconid parasite of, in Australia, **110.**
*exalbida, Chionaspis*.
*exaratum, Stomatoceras*.
*excisae, Chionaspis* (*Pinnaspis*).
*excultus, Mesochorus*.
*eximius, Elasmus*.
*exocarpi, Poliaspis*.
*Exocarpus cupressiformis*, Coccid on, in Australia, **21.**
*exornata, Disophrys*.

*expolitus, Mesochorus.*
*extensus, Aspidiotus* (*Neoleonardia*).

## F.

*Fagus sylvatica* (Beech), mosquitos breeding in, **45.**
*fallax, Diplosis.*
*farinicola, Arthrocnodax.*
*fasciata, Anisostena.*
*fasciipennis, Microgaster.*
*fatigans, Culex.*
Fernando Po, pests of cacao in, **201, 253.**
*Ficalbia*, characters of squama of, **343.**
*Ficalbia elegans*, re-description of, from Queensland, **271–273.**
*Ficalbia malfeyti*, **62**; early stages of, **67.**
*Ficalbia mediolineata*, **274.**
*fici, Chionaspis*; *Tachardia.*
*Ficus*, Coccid on, in S. Rhodesia, **356**; relation of *Glossina morsitans* to, **289.**
*Ficus mysorensis*, lac insect on, in India, **242.**
*ficus, Aspidiotus* (*Chrysomphalus*).
Fig, life-history of *Ocnerogyia amanda* on, in Iraq, **39, 40.**
Fiji, new Chalcid parasite of *Platyedra gossypiella* in, **256**; mosquitos in, **338, 339, 340.**
*fijiensis, Brachymeria.*
*filipes, Rachionotomyia* (*Rachisoura*).
*fimbripes, Aëdes* (*Geoskusea*).
*Finlaya*, a subgenus of *Aëdes*, *q.v.*
*fissidens, Hemiberlesia* (see *Aspidiotus gowdeyi*).
*Flacourtia hirtiuscula*, new Coccid on, in S. Rhodesia, **354.**
Flame Gun, description of, for use against locusts, **135, 138.**
*flava, Sipha.*
*flavida, Aphidoletes.*
*flavipennis, Aëdes* (*Finlaya*).
*flavipes, Apanteles.*
*florea, Myiatropa.*
*florum, Thrips.*
Flour, new Cecidomyiid in, in Naples, **122.**
*Fluggea microcarpa*, new Coccid on, in S. Rhodesia, **360.**
*fluggeae, Parlatoria.*
*fodiens, Aspidiotus* (*Chrysomphalus*).
*formosa, Phenacaspis.*
*Fornicia ceylonica*, parasite of *Natada nararia* in Ceylon, **107.**
France, Cecidomyiids predacious on Aphids in, **433, 434, 436, 438–440.**
*Frankliniella sulphurea*, food-plants of, in India, **79.**
*fraterculus, Anastrepha.*
*fraudatrix, Culex* (*Lophoceratomyia*).
*frauenfeldi, Afreutreta.*
*froggatti, Lepidosaphes.*
Fuchsin, formulae for staining with, **167, 224.**
*fullawayi, Diachasma.*
*fullo, Polyphylla.*
*fulva, Phaenobremia.*
*fumidus, Aëdes* (*Skusea*).
*fumipennis, Culex*; *Elasmus.*
*funereus, Aëdes.*
*Funtumia elastica*, Pierid on, in S. Rhodesia, **444.**
Furau, habits of tiger-beetle larva known as, in N. Nigeria, **403–406.**
*Furcaspis biformis*, **26.**
*Furcaspis* (*Paraonidiella*) *cladii*, on *Gahnia* in Australia, **26.**
*Furcaspis* (*Spinaspidiotus*) *oceanica*, **26.**
*furcillae, Aspidiotus.*
*furfurea, Aëdomyia.*
*furvus, Aëdes* (*Skusea*).
*fusca, Desvoidya* (see *Armigeres malayi*); *Glossina*; *Stegomyia* (see *Aëdes furvus*).
*fuscatus, Dacus.*
*fuscinervis, Apanteles.*

## G.

*Gahnia*, Coccid on, in Australia, **26.**
*Galleria mellonella, Nemeritis canescens* parasitic on, in U.S.A., **430.**
Game, relation of, to *Glossina morsitans* in S. Rhodesia, **378.**
*ganglbaueri, Haplothrips.*
*Gasterocercodes gossypii*, on cotton in Peru, **228.**
*Gazania uniflora*, new Trypetid on, in S. Africa, **401.**
*geniculatus, Aëdes.*
*Geoskusea*, a new subgenus of *Aëdes* (*q.v.*), **342.**
Germany, new Cecidomyiid in stored products in, **120**; Cecidomyiid predacious on Aphids in, **436.**
*Gerris*, **304.**
*gibber, Chionaspis* (*Dinaspis*).
*gidgei, Aspidiotus.*
*Gigantothrips elegans*, **71.**
*Gigantothrips gracilis*, distinct from *G. elegans*, **71.**
*gigas, Anopheles*; *Satanas.*
Ginger, new Hispid on, in Solomon Is., **234.**
*glauca, Macrosiphum rosae.*
*Glossina caliginea*, **1.**
*Glossina fusca*, in Belgian Congo, **1.**
*Glossina morsitans*, bionomics of, in S. Rhodesia, **279–301, 377–390**; Bom-

byliid and other parasites of, in Africa, **151–164, 283**; grass fires against, **377–390**; relation of game to, **378**; relation of, to types of forest, **379**.
*Glossina morsitans submorsitans*, new Bombyliid parasite of, in N. Nigeria, **151, 156**.
*Glossina newsteadi*, sp. n., from Belgian Congo, **1**.
*Glossina pallicera*, **1, 2, 4**.
*Glossina palpalis*, in Belgian Congo, **1, 4**.
*Glossina swynnertoni*, **377**.
*Glossina tabaniformis*, in Belgian Congo, **1**.
*Glossina tachinoides*, new Bombyliid parasite of, **151, 156**; in Nigeria, **151, 156, 282**.
*glossinae, Mutilla ; Syntomosphyrum*.
*Goeldia* (*Lesticocampa*), **312, 332**.
*Goeldia longipes*, characters of squama of, **343**.
*Goeldia* (*Lesticocampa*) *rapax*, **310**.
*Goeldia trichopus*, characters of squama of, **343**.
*Golofa aegeon*, on sugar-cane in Peru, **229**.
*gossypiella, Platyedra* (*Pectinophora*).
*gossypii, Aphis ; Gasterocercodes*.
*gowdeyi, Aspidiotus* (*Aonidiella*).
*gracilis, Gigantothrips*.
*grahami, Culex ; Eretmopodites*.
*graminicola, Nysius* (*Macroparius*).
*graminum, Toxoptera*.
*granarium, Macrosiphum*.
*grandiculus, Apanteles*.
*grandilobis, Lepidosaphes*.
*grandis, Anthonomus*.
Grapefruit, thrips on, in Sierra Leone, **75**.
*grassator, Lestodiplosis*.
*gregaria, Schistocerca*.
Groundnuts, thrips on, in India, **78, 79**.
*Guerciobremia* spp., predacious on Aphids in Italy, **439**.
Guiana, British, control of *Castnia licoides* on sugar-cane in, **192**; *C. daedalus* on coconut in, **192**.
Guiana, Dutch, *Castnia daedalus* on banana in, **192**.
Guiana, French, new weevil on cacao from, **204**.
*guiarti, Culex*.
*Gymnosporia*, Coccid on, in S. Rhodesia, **373**.
*Gynaikothrips chavicae*, on pepper in India, **79**.
*Gynaikothrips pallipes*, on pepper in India, **79**.

# H.

*Habrobracon brevicornis*, **425**.
*Habrobracon juglandis* (see *Microbracon hebetor*).
*Haemagogus*, characters of squama of, **343**.
*haemorrhoidalis, Heliothrips*.
*halifaxi, Lutzia*.
*hancocki, Anopheles theileri ; Microbracon*.
*Hapalia machaeralis*, Chalcid parasite of, in India, **413**.
*Haplothrips ceylonicus*, on coconut in F.M.S., **73**; food-plants of, in India, **79**.
*Haplothrips ganglbaueri*, **73**.
*Haplothrips ramakrishnai*, on chrysanthemum in India, **79**.
*Haplothrips soror*, food-plants of, in India, **79**.
*Haplothrips sororculus*, **73**.
*Haplothrips subtilissimus*, **74**.
*Haplothrips tenuipennis*, on tea in Assam, **78**.
*hargreavesi, Brachyurothrips*.
*Harpagomyia*, characters of squama of, **343**.
*hartii, Lepidosaphes*.
Hawaii, parasite of *Platyedra gossypiella* in, **256**; Cecidomyiid predacious on Aphid in, **438**.
*hawaiiensis, Lepidosaphes*.
Hawthorn, Coccid on, in Australia, **27**.
*hebetor, Microbracon*.
*hebrideus, Aëdes variegatus*.
*Hecabalodes anthaxiae*, gen. et sp. n., parasite of *Anthaxia congregata* in Sudan, **105**.
*Hecabolus*, **105**.
*hederae, Aspidiotus*.
Hedgehogs, destroying beetles in Ukraine, **96**.
*Heizmannia*, characters of squama of, **343**.
*helianthi, Aphis*.
*helichrysis, Phaenobremia*.
*Heliothis armigera*, Braconid parasite of, in Australia, **108**.
*Heliothrips haemorrhoidalis*, food-plants of, in India, **78**.
*Heliothrips indicus* (see *Selenothrips*).
*Heliotropium*, food-plant of *Agonoscelis versicolor* in Sudan, **216, 219**.
*Helodes*, breeding in tree-holes in Britain, **50**.
*Hemiberlesia* (see *Aspidiotus*).
*Hemiberlesia fissidens* var. *constricta* (see *Aspidiotus gowdeyi*).
*Hemichionaspis minor*, on cotton in Peru, **226**.

*hemimelas, Acanthiophilus.*
*Hemipenthes,* **151** (note).
*Heracleum sphondylium,* Aphids on, in Germany, **436.**
*Heterodendron oleaefolium,* Coccid on, in Australia, **23.**
*Hibiscus* spp., thrips on, in India, **79.**
*hilli, Culex* (*Lophoceratomyia*) ; *Lepidosaphes.*
*hippocastani, Melolontha.*
*histeroides, Tetroda.*
*histrio, Cephalolia.*
*Hodgesia,* characters of squama of, **343.**
*Hodgesia malayi,* early stages of, **63.**
*Hodgesia sanguinis,* early stages of, **60.**
*Homona coffearia,* new Chalcid parasite of, in Ceylon, **416.**
*homonae, Elasmus.*
*Hoplandrothrips bispinoides,* **75.**
*Hoplandrothrips bispinosus,* **75.**
*Hoplandrothrips coffeae,* sp. n., on coffee in Tanganyika, **75.**
*Hoplandrothrips hystrix,* sp. n., on grapefruit in Sierra Leone, **74.**
Hops, Aphid on, in Italy, **439.**
*Howardia dombeyae,* sp. n., on *Dombeya rotundifolia* in S. Rhodesia, **360.**
*humboldti, Castniomera.*
*humeralis, Aëdes* (*Chaetocruiomyia*).
*humilis, Opius.*
*humuli, Phorodon.*
*hutsoni, Elasmus.*
*Hyalopterus arundinis,* Cecidomyiids predacious on, in England, **438, 439.**
*Hyalopterus trirhoda,* Cecidomyiid predacious on, in England, **439.**
*Hyblaea puera,* parasites of, in India, **109, 414.**
*hyblaeae, Elasmus.*
*Hydatothrips ramaswamiahi,* food-plants of, in India, **79.**
*Hylobius abietis,* bionomics of, in Sweden, **245–250.**
*Hypera variabilis,* parasites of, **460.**
*Hyperaspis,* growth of larva of, **246.**
*hypsipylae, Apanteles.*
*hyrcanus, Anopheles.*
*Hystoneura setariae,* Cecidomyiid predacious on, **437.**
*hystrix, Hoplandrothrips.*

## I.

*idiota, Pentodon.*
*Illinoia pisi,* Cecidomyiid predacious on, **438.**
*imbricata, Chionaspis.*
*Impatiens noli-me-tangere,* Aphid on, in France, **437.**
*impatientis, Phaenobremia.*
*importunus, Apanteles.*
*imprimens, Aëdes* (*Aëdimorphus*).
*incertellus, Schoenobius.*
India, Braconid and Chalcidoid parasites in, **107, 109, 110, 111, 113, 177, 206, 208, 259, 414–416, 418, 451, 453, 454;** lac insects in, **242, 243;** bionomics and control of Pentatomids on rice in, **173–178;** economic status of thrips of, **77–79.**
*indica, Diaphania* (*Margaronia*) ; *Neoheegeria.*
*indicus, Dendrothrips; Elasmus; Panchaetothrips; Selenothrips* (*Brachyurothrips, Heliothrips*).
Indigo, thrips on, in India, **78, 79.**
*indotata, Diplosis.*
*ingrami, Anopheles rufipes ; Culex.*
*Inocarpus edulis,* mosquito breeding in hole in, **306.**
*inornata, Uranotaenia.*
*inornatus, Eretmopodites.*
Insects, in protected situations, control of, by parasites, **457–462.**
*Insizwa striatifrons,* gen. et sp. n., on *Gazania uniflora* in S. Africa, **400.**
*insubidus, Tylodes.*
*insulana, Earias.*
*intacta, Scirpophaga.*
*intermedius, Dysdercus.*
*interpunctella, Plodia.*
*Ipobracon peronatus,* associated with *Stirastoma depressum* in cacao logs in Trinidad, **205.**
Iraq, life-history of *Ocnerogyia amanda* on fig in, **39–40.**
*Iridomyrmex detectus,* predacious on *Plodia interpunctella,* **427.**
*Iridomyrmex rufoniger,* predacious on *Plodia interpunctella,* **427.**
*Ischnotrachelus theobromae,* sp. n., on cacao in Fernando Po, **201.**
*Ischnotrachelus viridipennis,* **201.**
*Isobremia kiefferi,* predacious on Aphids in France, **434;** Proctotrupid parasitic on, **434.**
*Isobremia sonchi,* predacious on Aphid in France, **434.**
*Isoneurothrips orientalis,* food-plants of, in India, **79.**
Italy, new Cecidomyiid in flour in, **122;** Cecidomyiids predacious on Aphids in, **434, 439, 440.**
*iyengari, Aëdes* (*Pseudoskusea*).

## J.

*jaceae, Macrosiphum.*
Jak (see *Artocarpus integrifolia*).
*japonica, Anopheles lindesaii.*
Jasmine, thrips on, in India, **79.**
*jeanneli, Dolichothrips.*

*johnstoni, Elasmus.*
*jonnaphila, Taeniothrips.*
*juglandis, Habrobracon* (see *Microbracon hebetor*).
*jujubae, Apanteles.*

## K.

*karnyi, Dolichothrips.*
*kiefferi, Isobremia.*
*kiefferiana, Phaenobremia.*
*Kigelia pinnata*, relation of *Glossina morsitans* to, **289.**
*kiggelariae, Chionaspis* (*Poliaspis*).
*Kleothrips subramanii*, on coconut in India, **79.**
*kochi, Aëdes* (*Finlaya*) *; Anuraphis.*
Kola, new thrips on, in Sierra Leone, **73.**

## L.

Lac Insects, first stage larva of, **241–243;** *Eublemma amabilis* predacious on, in India, **418.**
*Laccifer* (*Lakshadia*) *communis*, on *Ficus mysorensis* in India, **242;** larva of winged male of, **242.**
*Laccifer* (*Lakshadia*) *mysorensis*, on *Shorea talura* in India, **243;** larva of female of, **243.**
*lamborni, Elasmus.*
*Lamprosema diemenalis*, Chalcid parasite of, in Malaya, **413.**
*lanigera, Poliaspis.*
*lanigerum, Eriosoma.*
*Lantana*, thrips on, in India, **79.**
Larch, Aphid on, in Italy, **440.**
*lardarius, Dermestes.*
*laticollis, Bryocoropsis.*
*lefroyi, Taeniothrips.*
*Lema cyanella*, **6.**
*Lema melanopa*, bionomics and control of, in Britain, **5–14.**
*Lema tristis*, **6.**
Lemon (*Citrus limonum*), Aphid on, in Italy, **439;** Coccid on, in S. Rhodesia, **356.**
*Lepidosaphes beckii*, on orange in Peru, **229;** in S. Rhodesia, **375.**
*Lepidosaphes bicornis* var. *alba*, on *Eucalyptus rostrata* in Australia, **34.**
*Lepidosaphes casuarinae*, **30.**
*Lepidosaphes chitinosa*, **33.**
*Lepidosaphes chitonosa* (see *L. froggatti*).
*Lepidosaphes contorta*, sp. n., on *Acacia* in Tasmania, **35.**
*Lepidosaphes defecta*, in Australia, **35.**
*Lepidosaphes distincta*, sp. n., on *Zizyphus jujuba* in S. Rhodesia, **375.**
*Lepidosaphes froggatti*, n.n. for *L. chitonosa* Frogg. nec *L. chitinosa*, Ldgr., **33.**
*Lepidosaphes grandilobis*, **32.**
*Lepidosaphes hartii*, sp. n., on *Banksia serrata* in Australia, **31.**
*Lepidosaphes hawaiiensis*, **362.**
*Lepidosaphes hilli*, sp. n., on *Casuarina* in Australia, **29.**
*Lepidosaphes moorsi* (see *L. hawaiiensis*).
*Lepidosaphes multipora*, on *Pittosporum undulatum* in New Zealand, **36;** on *Acacia stricta* in Australia, **36.**
*Lepidosaphes nivea*, **35.**
*Lepidosaphes pandani*, sp. n., on *Pandanus odoratissimus* in Australia, **33.**
*Lepidosaphes subnivea*, sp. n., on *Calycothrix tetragona* in Australia, **34.**
*leptoura, Apanteles.*
*Leptoxyda brevistriga* (see *Dacus*).
*Lesticocampa* (see *Goeldia*).
*Lestodiplosis grassator*, predacious on Aphid in Canada, **440.**
*Lestodiplosis pini*, predacious on Aphids in England, **440.**
*Lestodiplosis raphani*, sp. n., in radish seed in Denmark & Germany, **119.**
*Leucas urticifolia*, food-plant of *Agonoscelis versicolor* in Sudan, **216, 219.**
*leucopus, Eretmopodites.*
*Leucotaeniella*, **393.**
*licoides, Castnia.*
*lignoptera, Trypanea.*
*lignosellus, Elasmopalpus.*
*Ligustrum vulgare*, Aphid on, in Italy, **439.**
Lilac, new Coccid on, in Australia, **17.**
*Limatus*, characters of squama of, **343.**
*limbatella, Afreutreta millepunctata.*
*Limnerium stellenboschensis* (see *Eulimneria*).
*lindesaii, Anopheles.*
*lineus, Thyridanthrax.*
*liriodendri, Macrosiphum.*
*lloydi, Thyridanthrax.*
Locust, Brown (see *Locustana pardalina*).
Locust, Desert (see *Schistocerca gregaria*).
Locust, Lesser Migratory (see *Melanoplus mexicanus atlanis*).
Locust, Moroccan (see *Dociostaurus maroccanus*).
Locust, Red (see *Nomadacris septemfasciata*).
Locust, Rocky Mountain (see *Melanoplus mexicanus atlanis*).
Locust, South American (see *Schistocerca paranensis*).
*Locusta migratoria*, poison bait against, in Sudan, **99;** nomenclature of

phases and geographical forms of, **261–264.**
*Locusta migratoria rossica*, subsp. n., from Central Russia, **263.**
*Locustana pardalina*, nomenclature of phases of, **264.**
Locusts, bionomics and control of, in Palestine, **123–139**; use of flame guns against, **135, 138**; formula for poison bait against, in Sudan, **99–101**; nomenclature of phases of, **261–264.**
*Lonchocarpus capassa*, relation of *Glossina morsitans* to, **289.**
*longiforceps, Aëdes* (*Geoskusea*).
*longipes, Goeldia.*
*longirostris, Aëdes* (*Rhinoskusea*).
*longispina, Aspidiotus* (*Morganella*).
*longistylus, Taeniothrips.*
*Lophoceratomyia* (see *Culex*).
*loranthi, Aspidiotus.*
*Loranthus*, new Coccids on, in S. Rhodesia, **363, 371.**
*Loranthus pendulus*, Coccids on, in Australia, **22, 25.**
*loreyi, Cirphis.*
*lounsburyi, Chionaspis* (*Dinaspis*); *Dacus.*
*Loxocephalus*, **208.**
Lucerne (*Medicago sativa*), thrips on, in India, **79**; food-plant of *Agonoscelis versicolor* in Sudan, **216.**
*lugens, Thyridanthrax* (see *T. abruptus*).
*lurida, Scotinophara.*
*lutea, Disophrys.*
*lutens, Elasmus.*
*Lutzia*, **332**; characters of squama of, **343.**
*Lutzia halifaxi*, in Solomon Is., **307.**

## M.

*machaeralis, Hapalia.*
*Macroparius graminicola* (see *Nysius*).
*macrorosae, Phaenobremia.*
*Macrosiphoniella absinthii*, Cecidomyiid predacious on, in England, **439.**
*Macrosiphoniella balsamines*, Cecidomyiid predacious on, in France, **437.**
*macrosiphoniellae, Guerciobremia.*
*macrosiphonis, Guerciobremia.*
*Macrosiphum granarium*, Cecidomyiid predacious on, **438.**
*Macrosiphum jaceae*, Cecidomyiid predacious on, in England, **439.**
*Macrosiphum liriodendri*, Cecidomyiid predacious on, **438.**
*Macrosiphum rosae*, Cecidomyiid predacious on, in France, **434.**
*Macrosiphum rosae* var. *glauca*, Cecidomyiid predacious on, in Scotland, **437.**
*Macrosiphum schranki*, Cecidomyiid predacious on, in Britain, **439.**
*Macrosiphum sonchella*, Cecidomyiid predacious on, **438.**
*Macrosiphum sonchi*, Cecidomyiid predacious on, in France, **434.**
*maculatus, Anopheles.*
*maculipalpis, Anopheles.*
*maculipennis, Anopheles.*
*maculosus, Myllocerus.*
Madagascar, nomenclature of locusts in, **263.**
*maidis, Aphis.*
Maize, thrips on, in India, **79.**
*major, Berlesaspis spinifera.*
Malaya, new Anopheline from, **323**; coconut pests in, **74, 409**; parasitic Hymenoptera from, **113, 413.**
*malayi, Armigeres*; *Hodgesia.*
*malevolus, Apanteles.*
*malfeyti, Ficalbia.*
*malifoliae, Anuraphis* (see *A. roseus*).
*manducator, Alysia.*
Mango, thrips on, in India, **79**; Coccid on, in Natal, **345.**
Mangrove, new Coccid on, in Australia, **21.**
*Marasmius trapezalis*, on sugar-cane in Peru, **229.**
*Margaronia indica* (see *Diaphania*).
*marginata, Aphidoletes.*
*marina, Phaenobremia.*
*maroccanus, Dociostaurus.*
*marshalli, Anopheles.*
*martinii, Metriocnemus.*
*mashonae, Aspidiotus.*
*mashonaensis, Uranotaenia.*
*masii, Elasmus.*
Mauritius, new Braconid parasite of *Cirphis unipuncta* in, **108**; parasite of *Phthorimaea* in, **104.**
*mazoeensis, Aspidiotus* (*Diaspidiotus*).
*media, Poliaspis.*
*Medicago sativa* (see Lucerne).
*mediolineata, Ficalbia.*
Mediterranean Fruit-fly (see *Ceratitis capitata*).
*Megaculex*, a subgenus of *Mimomyia*, *q.v.*
*Megarhinus*, **332**; characters of squama of, **343.**
*Megarhinus brevipalpis*, **62.**
*Melaleuca*, new Coccids on, in Australia, **16, 24, 25.**
*melaleucae, Chionaspis* (*Pinnaspis*).
*melanopa, Lema.*
*Melanoplus mexicanus atlanis*, nomenclature of phases of, **264.**
*melanorhodon, Anacridium moestum.*
*mellonella, Galleria.*

*Melolontha hippocastani*, bionomics and control of, on vines in Ukraine, **96.**
*Melolontha melolontha*, bionomics and control of, on vines in Ukraine, **96.**
*mendosa, Dasychira.*
*mendosae, Apanteles.*
*meridionalis, Phaenobremia.*
*Mesochorus concinnatus*, sp. n., parasite of *Danais chrysippus* in S. Africa, **105.**
*Mesochorus decoratus*, **104.**
*Mesochorus excultus*, **104.**
*Mesochorus expolitus*, sp. n., hyperparasite of *Acraea acerata* in Uganda, **104.**
*Mesochorus ornatus*, **104, 105.**
*mesopotamiae, Anopheles hyrcanus.*
*metallica, Mimomyia.*
*Metamasius*, on sugar-cane in Peru, **230.**
*meticulosalis, Terastia.*
*Metriocnemus martinii*, breeding in tree-holes in Britain, **50.**
*mexicanus, Melanoplus.*
*miachaetessa, Aëdes* (*Cancraëdes*).
*Microbracon hancocki*, new parasite of, in Uganda, **257.**
*Microbracon hebetor*, biology of, **425–427.**
*Microdontomerus anthonomi*, hosts of, in U.S.A., **255.**
*Microdus aciculatus*, parasite of *Earias* spp. in Uganda, **207.**
*Microgaster fasciipennis*, **453.**
*Microgaster perniciosa*, **453.**
*Microgaster persimilis*, **453.**
*Microgaster plecopterae*, sp. n., parasite of *Plecoptera reflexa* in India, **451.**
*Microphthalma disjuncta*, parasite of *Polyphylla fullo* in Ukraine, **96.**
*Microplitis basalis*, **207.**
*Microplitis bimaculatus*, **206, 207.**
*Microplitis radicalis*, sp. n., from China, **206.**
*micropterus, Aëdes* (*Dendroskusea*).
*Microstigmus myersi*, sp. n., from Trinidad, **407.**
*Microstigmus theridii*, **407, 408.**
*migratoria, Locusta.*
*migratorius, Dysdercus.*
*millepunctata, Afreutreta.*
Millet (see *Sorghum*).
*mimeticus, Culex.*
*Mimomyia*, characters of squama of, **343.**
*Mimomyia metallica*, **271**; early stages of, from Queensland, **273–274.**
*Mimomyia mimomyiaformis*, **332, 333.**
*Mimomyia* (*Megaculex*) *plumosa*, early stages of, **332.**
*mimomyiaformis, Mimomyia.*
*Mimusops elengi*, thrips on, in India, **78.**
*minima, Chionaspis* (*Pinnaspis*).
*minor, Hemichionaspis.*
*minutum, Trichogramma.*
*minutus, Anopheles.*
*mirabilis, Phaonia.*
Mistletoe (see *Loranthus*).
*mlanje, Apanteles.*
*moestum, Anacridium.*
Moles, predacious on *Polyphylla fullo* in Ukraine, **97.**
*moloiensis, Aëdes* (*Chaetocruiomyia*).
Moluccas, new Hispid on coconut in, **85.**
*Monobremia subterranea*, predacious on Aphid in France, **440.**
*Monotes glaber*, Coccids on, in S. Rhodesia, **358–359.**
*monotes, Aspidiotus* (*Aonidiella*); *Chionaspis communis.*
*moorsi, Lepidosaphes* (see *L. hawaiiensis*).
*Morganella* (see *Aspidiotus*).
*Morinda tinctoria*, thrips on, in India, **79.**
*morsitans, Culicella; Glossina.*
Mosquitos, from Africa, **59–68, 322–327**; breeding in tree-holes in Britain, **45–58**; new species of, from Queensland, **271–277**; from Solomon Is., **303–316**; relation of algae to larvae of, **53–57**; graphical representation of instar records of, **195–198**; squamal fringe as a generic character in, **342.**
*moucheti, Culex.*
*msolonus, Aspidiotus.*
*Mucidus*, **332**; characters of squama of, **343.**
*muiri, Acanthiophilus.*
*multipora, Lepidosaphes.*
*mundata, Diacrisia.*
*Mutilla benefactrix*, parasite of *Glossina morsitans* in Nyasaland, **283**; in S. Rhodesia, **287.**
*Mutilla glossinae*, **384**; parasite of *Glossina morsitans* in Africa, **283**; bionomics of, in S. Rhodesia, **284–285, 297, 298.**
*myersi, Microstigmus.*
*Myersia* (see *Rhypodes*).
*Myiatropa florea*, breeding in tree-holes in Britain, **50.**
*mylloceri, Dinocampus.*
*Myllocerus maculosus*, new Braconid parasite of, on cotton in India, **203.**
*Mylothris chloris*, new Braconid parasite of, in S. Nigeria, **444.**
*mysorensis, Laccifer* (*Lakshadia*).
*Myzus cerasi*, Cecidomyiids predacious on, **435, 438, 439.**
*Myzus persicae*, Cecidomyiid predacious on, **438.**

# N.

*Natada nararia*, parasite of, in Ceylon, **107.**
Natal, Coccid on mango in, **345.**
*natalensis*, *Chionaspis* (*Phenacaspis*) (see *C. dilatata*) ; *Nysius*.
*neavei*, *Apanteles*.
*negundinis*, *Chaitophorus*.
*Nemeritis canescens*, parasite of *Ephestia* and *Galleria mellonella*, **430.**
*Neoheegeria indica*, **73.**
*Neoleonardia extensus* (see *Aspidiotus*).
*Neopecomyia uniannulata* (see *Aëdes*).
*Nepeta cataria*, Aphid on, in England, **437.**
*nephantidis*, *Elasmus*.
*Nephantis serinopa*, parasites of, in India, **113, 415.**
*Nephopteryx rhodobasalis*, Braconid parasite of, in India, **111.**
*nerii*, *Aphis*.
*Nerium oleander*, Coccid on, in Australia, **27.**
*newsteadi*, *Glossina*.
New Zealand, Coccid on *Pittosporum undulatum* in, **36.**
Nigeria, notes on *Dysdercus* spp. on cotton in, **38** ; new Braconid parasites from, **444, 446.**
Nigeria, Northern, habits of tiger-beetle larva known as Furau in, **403–406.**
*nigerrima*, *Uranotaenia*.
*nigerrimus*, *Anopheles hyrcanus*.
*nigrescens*, *Pardomyia aurantia*.
*nigripes*, *Uranotaenia*.
*nigrofasciatus*, *Dysdercus*.
*nilgiricus*, *Anopheles lindesaii*.
*nilgiriensis*, *Thrips*.
*Nippia*, gen. n., **392.**
*Nippia alboscutellata*, sp. n., from S. Africa, **393.**
*Nitella*, **271.**
*nitens*, *Poliaspis*.
*nivea*, *Lepidosaphes*.
*Nomadacris septemfasciata*, nomenclature of phases of, **264.**
*nonagriae*, *Apanteles* (see *A. flavipes*).
*Notonecta*, **304.**
*notoscriptus*, *Aëdes*.
*novitius*, *Nysius* (*Aphanus*).
*nuciferae*, *Aulostyrax* ; *Promecotheca*.
Nyasaland, new Braconid parasites from, **445, 448, 450.**
*nyasaensis*, *Apanteles pistrinariae*.
*Nysius*, morphological characters of, **267.**
*Nysius albidus*, in Sierra Leone, **268.**
*Nysius binotatus*, re-description and synonymy of, **267.**
*Nysius clavicornis* (see *Rhypodes zealandicus*).
*Nysius* (*Macroparius*) *graminicola*, characters of, **269.**
*Nysius natalensis*, sp. n., from S. Africa, **269.**
*Nysius novitius* (see *Aphanus*).
*Nysius pallens* (see *N. binotatus*).
*Nysius pallidus*, sp. n., from S. Africa, **269.**
*Nysius stâli*, sp. n., from S. Africa, **268.**
*Nysius zealandicus* (see *Rhypodes*),

# O.

Oat, food-plant of *Lema melanopa* in Britain, **9.**
*obscura*, *Uranotaenia*.
*obscurata*, *Brachymeria*.
*obtusifrons*, *Sarcophaga*.
*oceanica*, *Furcaspis* (*Spinaspidiotus*).
*ochropyga*, *Sarcophaga*.
*Ocimum basilicum*, food-plant of *Agonoscelis versicolor* in Sudan, **216, 219.**
*Ocnerogyia amanda*, life-history of, on fig in Iraq, **39–40.**
*Octotoma tessellata*, sp. n., on *Canavalia ensiformis* in Brazil, **85.**
*Odoniella apicalis*, **254.**
*oidipodeios*, *Eretmopodites*.
*oleae*, *Parlatoria*.
*olethrius*, *Brachymeria*.
*Oliarus cocosivora*, sp. n., on coconut in Malaya, **409.**
*oligochaetus*, *Anaphothrips*.
Olive, Coccid on, in Australia, **27.**
*Omorgus phthorimaeae*, **104.**
Onion, thrips on, in Africa & India, **73, 78.**
*ononidis*, *Therioaphis*.
*Ononis repens*, Aphid on, in England, **433.**
*Opifex*, characters of squama of, **343.**
*Opius afreutretae*, **114.**
*Opius humilis*, inter-relation of, with other parasites of *Ceratitis capitata*, **142, 146–148.**
*Opius phorelliae*, sp. n., parasite of *Phorellia peringueyi* in S. Africa, **113.**
*Opius vittator*, **114.**
Orange (*Citrus aurantium*), thrips on, in India, **79** ; scale-insects on, in Peru, **229** ; Coccids on, in S. Rhodesia, **356, 375.**
*ordinarius*, *Eurhynchothrips*.
*oreas*, *Diplosis*.
*orientalis*, *Anoxia* ; *Isoneurothrips*.
*ornata*, *Guerciobremia*.

*ornatus, Aëdes funereus ; Mesochorus.*
*Orthopodomyia*, characters of squama of, **343.**
*Orthopodomyia pulchripalis*, breeding in tree-holes in Britain, **49, 54;** food of larva of, **156.**
*oryzae, Rhaconotus ; Thrips.*
*Oxycephala*, **235.**
*Oxysarcodexia peltata, Paratheresia signifera* confused with, in Argentina, **199;** a synonym of *Sarcophaga obtusifrons*, **199** (note).

## P.

*padi, Anuraphis.*
Palestine, locust invasion of, **128–139;** aerial survey of citrus plantations in, **431.**
*pallens, Nysius* (see *N. binotatus*).
*palliceva, Glossina.*
*pallidocinctus, Apanteles.*
*pallidus, Nysius.*
*pallipes, Gynaikothrips.*
Palm, Coccid on, in Australia, **23;** *Nephantis serinopa* on, in India, **415;** Coccid on, in S. Rhodesia, **356.**
Palm, Sago, mosquito breeding in, **306.**
*palmi, Thrips.*
*palpalis, Glossina.*
*paludicolae, Apanteles.*
*Panchaetothrips indicus*, food-plants of, in India, **79.**
*pandani, Lepidosaphes.*
*Pandanus odoratissimus*, new Coccid on, in Australia, **32.**
*pandu, Thrips.*
*Panurothrips* (see *Gigantothrips*).
*Papaver*, Aphids on, in Italy, **434.**
*papilionis, Apanteles.*
*papuensis, Culex* (*Culiciomyia*).
Paradichlorobenzene, use of, against vine pests in Ukraine, **98.**
*Parafreutreta*, gen. n. for *Camaromyia conferta*, **396.**
*Parafreutreta bryanti*, sp. n., on *Senecio longiflora* in S. Africa, **398.**
*Parafreutreta conferta*, on *Senecio angulatus* in Natal, **397.**
*Parafreutreta pretoriae*, sp. n., from S. Africa, **397.**
*paranensis, Schistocerca.*
*Paraonidiella cladii* (see *Furcaspis*).
Parasites, in the control of insects living in protected situations, **457–462.**
Parasitism, Multiple, relation of, to biological control, **141–149.**
*Paratheresia signifera*, parasite of *Diatraea saccharalis* in Argentina, **199;** synonymy of, **200.**
*Pardalaspis scaevolae*, sp. n., on *Scaevola lobelia* in Natal, **394.**
*Pardalaspis stictica*, **394, 395.**
*pardalina, Locustana.*
*Pardomyia*, characters of squama of, **343.**
*Pardomyia aurantia* var. *nigrescens*, n., from Solomon Is., **305, 314.**
*Parlatoria fluggeae*, sp. n., on *Fluggea microcarpa* in S. Rhodesia, **359.**
*Parlatoria oleae*, **360.**
Peach, food-plant of *Anastrepha fraterculus* in Peru, **229.**
Pear, food-plant of *Anastrepha fraterculus* in Peru, **229.**
*pectinatus, Aspidiotus* (*Diaspidiotus*).
*Pectinophora* (see *Platyedra*).
*pectoralis, Dacus.*
*peditaeniatus, Anopheles hyrcanus* (see *A. hyrcanus nigerrimus*).
*peltata, Sarcophaga* (*Oxysarcodexia*) (see *S. obtusifrons*).
*pembaensis, Aëdes* (*Skusea*).
*Pennisetum typhoideum* (Cumbu), thrips on, in India, **79.**
*Pentodon idiota*, bionomics and control of, on vines in Ukraine, **96.**
Pepper (*Piper nigrum*), thrips on, in India, **79.**
*perfidus, Endaphis.*
*Perilampsis*, **393.**
*Perilampsis amazuluana*, sp. n., from Zululand, **394.**
*Perilampsis diadematа*, in S. Rhodesia, **394.**
*Perilampsis pulchella*, **394.**
*peringueyi, Phorellia.*
*periskeletus, Aëdes* (*Dendroskusea*).
*perniciosa, Microgaster.*
*peronatus, Ipobracon.*
*persicae, Myzus.*
*persimilis, Microgaster.*
Peru, status of economic entomology in, **225–231.**
*Phaenobremia aphidimyza*, **442** (note); predacious on Aphids, **435.**
*Phaenobremia aphidisuga*, predacious on Aphids in Germany & France, **436.**
*Phaenobremia aphidivora*, predacious on Aphids in Germany, **436.**
*Phaenobremia basalis*, in U.S.A., **436.**
*Phaenobremia borealis*, in U.S.A., **436.**
*Phaenobremia cardui*, predacious on Aphid in France, **436.**
*Phaenobremia carnifex*, predacious on Aphid in Astrakhan, **436.**
*Phaenobremia cucumeris*, predacious on Aphid in U.S.A., **436.**
*Phaenobremia fulva*, predacious on Aphid in Canada, **436.**
*Phaenobremia helichrysis*, predacious on Aphid in Britain, **437.**

*Phaenobremia impatientis*, predacious on Aphid in France, **437.**
*Phaenobremia kiefferiana*, predacious on Aphids in Austria, **437.**
*Phaenobremia macrorosae*, predacious on Aphid in Scotland, **437.**
*Phaenobremia marina*, predacious on Aphid in U.S.A., **437.**
*Phaenobremia meridionalis*, predacious on Aphids, **437**; life-history of, **438.**
*Phaenobremia rosea*, predacious on Aphid in England, **438.**
*Phaenobremia rosivora*, predacious on Aphids in U.S.A., **438.**
*Phaenobremia urticariae*, predacious on Aphid in France, **438.**
*Phaenobremia vacunae*, predacious on Aphid in France, **439.**
*Phalaris canariensis* (Canary Grass), food-plant of *Lema melanopa* in Britain, **9.**
*Phaonia mirabilis*, breeding in tree-holes in Britain, **50.**
*Pharangispa purpureipennis*, gen. et sp. n., on ginger in Solomon Is., **233.**
*Phenacaspis* (see *Chionaspis*).
*philipi, Culex.*
Philippines, Chalcidoid parasites in, **256, 413, 414, 416, 421.**
*philippinensis, Elasmus.*
*Phleum pratense*, food-plant of *Lema melanopa* in Britain, **9.**
*Phoenix dactylifera*, Coccid on, in S. Rhodesia, **364.**
*Phoenix reclinata*, relation of *Glossina morsitans* to, **289.**
*Phorellia peringueyi*, new Braconid parasite of, in S. Africa, **114.**
*phorelliae, Opius.*
*Phorodon humuli*, Cecidomyiids predacious on, **438, 439.**
*phorodontis, Guerciobremia.*
Photography, Aerial, utility of, in entomological field work, **431.**
*Phragmatiphila truncata*, Braconid parasite of, in Australia, **108.**
*Phthorimaea*, parasite of, in Mauritius, **104.**
*phthorimaeae, Omorgus.*
*phyllolabis, Aëdes* (*Aëdimorphus*).
*Phylloxera*, **95.**
*Phylloxera vastatrix*, Cecidomyiid predacious on, in Canada, **440.**
*Phytometra* (*Plusia*), Braconid parasite of, in India, **109.**
*Phytonomus posticus* (see *Hypera variabilis*).
*pictus, Anopheles hyrcanus.*
*pilosa, Anoxia.*
*pini, Lestodiplosis.*
Pink Bollworm (see *Platyedra gossypiella*).
*Pinnaspis* (see *Chionaspis*).
*Pinus*, Coccid on, in S. Rhodesia, **356.**
*Pinus strobus*, Aphids on, in England, **440.**
*Piper nigrum* (see Pepper).
*pipiens, Culex.*
*pisi, Illinoia.*
*pistrinariae, Apanteles.*
*Pitangus sulphuratus*, feeding on *Castnia licoides* in Br. Guiana, **192.**
*pittospori, Chionaspis* (*Dinaspis*).
*Pittosporum undulatum*, Coccids on, in Australia and New Zealand, **27, 36.**
*Pittosporum viridiflorum*, new Coccid on, in S. Rhodesia, **374.**
*platanoides, Drepanosiphum.*
*Platyedra* (*Pectinophora*) *gossypiella*, measures against, in Egypt, **41–43**; not occurring in Peru, **230**; new Chalcidoid parasites of, **255–259, 414**; genitalia of, **179–185.**
*Platyedra* (*Pectinophora*) *scutigera* (Queensland Pink Bollworm), compared with *P. gossypiella*, **179–185.**
*Platypria*, **233.**
*pleccau, Anopheles* (see *A. lindesaii japonicus*).
*Plecoptera reflexa*, new Braconid parasites of, in India, **453, 454.**
*plecopterae, Microgaster.*
*Plodia interpunctella*, natural enemies of, in Australia, **425–430.**
*plumbeus, Anopheles.*
*plumosa, Mimomyia* (*Megaculex*).
*Plusia* (see *Phytometra*).
*Pogostemon patchouli, Psara stultalis* on, in Malaya, **413.**
*Poliaspis callitris*, sp. n., on *Callitris* in Australia, **19.**
*Poliaspis exocarpi*, food-plants of, in Australia, **21.**
*Poliaspis higgelariae* (see *Chionaspis*).
*Poliaspis lanigera*, sp. n., on mangrove in Australia, **20.**
*Poliaspis media*, **19.**
*Poliaspis nitens*, **21.**
*Poliaspis syringae*, sp. n., on lilac in Australia, **17.**
*Polyphylla fullo*, bionomics and control of, on vines in Ukraine, **95, 96.**
*Polystenidea*, **106.**
Pomegranate, thrips on, in India, **79.**
*pomi, Aphis.*
*posticus, Phytonomus* (see *Hypera variabilis*).
Potato, thrips on, in India, **78.**
*Pourretia coarctata*, **192.**
*pretoriae, Parafreutreta.*
*pretoriensis, Anopheles.*
*prodeniae, Apanteles.*
*Promecotheca alpiniae*, sp. n., on *Alpinia* in Solomon Is., **238.**

*Promecotheca cumingi*, **83, 85.**
*Promecotheca nuciferae*, sp. n., on coconut in Celebes, **81.**
*Promecotheca soror*, sp. n., on coconut in Moluccas, **84.**
*Prosopolepis*, a subgenus of *Wyeomyia*, *q. v.*
*Protea*, Coccid on, in S. Rhodesia, **345.**
*proteae, Chionaspis* (see *C. distincta*).
*pruina, Culex.*
*Psara stultalis*, Chalcid parasite of, in Malaya, **413.**
*Pseudaonidia articulatus* (see *Aspidiotus*).
*Pseudaonidia stenophyllae*, sp. n., on *Acacia stenophylla* in Australia, **27.**
*Pseudaonidia tesserata*, on *Monotes glaber* in S. Rhodesia, **359.**
*pseudobrassicae, Aphis.*
*Pseudolachnostylis* spp., new Coccid on, in S. Rhodesia, **349.**
*pseudopictus, Anopheles hyrcanus.*
*pseudoscutellaris, Aëdes variegatus.*
*Pseudoskusea*, a subgenus of *Aëdes*, *q. v.*
*Psorophora*, **332;** characters of squama of, **343.**
*Psyche albipes*, new Chalcid parasites of, in Ceylon, **412, 418.**
*puberula, Agonoscelis.*
*puera, Hyblaea.*
*pulchella, Perilampsis.*
*pulchripalpis, Orthopodomyia.*
*punctatissimus, Aëdes* (*Dendroskusea*).
*punctipes, Aëdes* (*Dendroskusea*).
*punctocostalis, Aëdes* (*Banksinella*).
*punctulatus, Anopheles.*
*purpureipennis, Pharangispa.*

## Q.

*quadrimaculata, Uranotaenia.*
*quasiornata, Rachionotomyia.*
Queensland, identity of pink bollworm of, **179–185.**
Quince, Aphids on, in Italy, **439.**
*quinquevittatus, Eretmopodites.*

## R.

*Rachionotomyia*, characters of squama of, **343.**
*Rachionotomyia atripes*, **310.**
*Rachionotomyia caledonica*, **310, 337, 338.**
*Rachionotomyia distigma*, **304.**
*Rachionotomyia* (*Rachisoura*) *filipes*, in Solomon Is., **305;** early stages of, **310–312.**
*Rachionotomyia quasiornata*, **304.**
*Rachionotomyia rotumana*, sp. n., from Fiji, **337.**
*Rachionotomyia solomonis*, in Solomon Is., **305;** early stages of, **308–310.**
*Rachisoura filipes* (see *Rachionotomyia*).
*radians, Euxoa.*
*radiantis, Apanteles.*
*radicalis, Microplitis.*
Radish (*Raphanus sativum*), new Cecidomyiid in seeds of, in Denmark and Germany, **120.**
Ragi (see *Eleusine*).
*ramakrishnae, Anaphothrips; Arrhenothrips.*
*ramakrishnai, Haplothrips.*
*ramaswamiahi, Hydatothrips.*
*rapax, Goeldia* (*Lesticocampa*).
*raphani, Lepidosaphes.*
*recurvata, Aphidoletes.*
*reflexa, Plecoptera.*
*refutans, Anopheles gigas.*
*reginae, Aëdes* (*Dendroskusea*).
*regularis, Diaspis.*
*reticulata, Chionaspis* (*Dinaspis*).
*Rhabdotohispa scotti*, **233, 237.**
*Rhaconotus oryzae*, sp. n., from India, **205.**
*Rhaconotus scirpophagae*, **206.**
*Rhaconotus sudanensis*, **206.**
*rhanis, Synopeas.*
*Rhipiphorothrips cruentatus*, food-plants of, in India, **78.**
*Rhochmopterum*, **395.**
Rhodesia, Southern, Coccidae of, **345–376;** bionomics and control of *Glossina morsitans* in, **279–301, 377–390.**
*rhodesiensis, Aspidiotus* (*Hemiberlesia*).
*rhodobasalis, Nephopteryx.*
*rhodophaga, Dasyneura.*
*Rhopalosiphum sonchi*, Cecidomyiid predacious on, **438.**
*Rhynchothrips vichitravarna*, on *Mimusops elengi* in India, **78.**
*Rhypodes*, synonymy of, **269.**
*Rhypodes* (*Nysius*) *zealandicus*, synonymy of, **269.**
*ribis, Capitophorus.*
Rice, pests of, in India, **77, 173–178, 206;** thrips on, in Java, **77.**
*Rondaniella* (see *Guerciobremia*).
*rosae, Macrosiphum.*
*rosarum, Capitophorus.*
Rose, thrips on, in India, **78.**
*rosea, Phaenobremia.*
*roseus, Anuraphis.*
*rosivora, Phaenobremia.*
*rossi, Aspidiotus* (*Chrysomphalus*).
*rotumana, Rachionotomyia.*
*rotundiloba, Chionaspis.*
*rubecula, Apanteles.*
*rubrocinctus, Selenothrips.*

*Rubus*, **111.**
*ruficollis, Dysdercus.*
*ruficrus, Apanteles.*
*rufipes, Anopheles.*
*rufiventris, Apanteles.*
*rufolimba, Castnia humboldti* (see *C. drucei*).
*rufoniger, Iridomyrmex.*
Russia, Cecidomyiids predacious on Aphids in, **435, 436;** new form of *Locusta migratoria* from, **263.**
*rusticus, Aëdes.*
*rutherfordi, Tryphactothrips.*
*rutilus, Dinocampus.*

## S.

*Sabethes*, characters of squama of, **343.**
*Sabethinus*, **312.**
*Sabethoides*, characters of squama of, **343.**
*saccharalis, Diatraea.*
*sacchari, Aclerda; Aphis.*
*saccharidis, Eumycterus.*
*saccharinae, Cephalolia.*
*sagax, Apanteles.*
*Sahlbergella singularis*, on cacao in Fernando Po, **253, 254.**
*Salix*, relation of *Glossina morsitans* to, **289.**
*Salix cinerea*, Aphid on, in England, **440.**
*salutaris, Thyridanthrax.*
*samoana, Aëdes* (*Finlaya*) *kochi.*
*sanguinis, Hodgesia.*
*Sapium mannianum*, new Coccid on, in S. Rhodesia, **363.**
*Sarcophaga diatraeae* (see *Paratheresia signifera*).
*Sarcophaga obtusifrons*, synonymy of, **199** (note).
*Sarcophaga ochropyga*, **199.**
*Sarcophaga peltata* (see *S. obtusifrons*).
*Satanas gigas*, predacious on *Polyphylla fullo* in Ukraine, **96.**
*saxatilis, Diplosis.*
*Scaevola lobelia*, new Trypetid on, in Natal, **395.**
*scaevolae, Parŧalaspis.*
*Schistocerca gregaria*, bionomics and control of, in Palestine, **123–139;** poison bait against, in Sudan, **99–101;** nomenclature of phases of, **264.**
*Schistocerca paranensis*, nomenclature of phases of, **264.**
*Schoenobius incertellus* (*bipunctifer*), parasite of, in rice in India, **206.**
*schranki, Macrosiphum.*
*schwetzi, Culex.*
*Scirpophaga intacta*, new Chalcid parasite of, in Java, **418.**
*scirpophagae, Rhaconotus.*
*Scirtothrips dorsalis*, food-plants of, in India, **78.**
*Scolia*, parasite of *Polyphylla fullo* in Ukraine, **96.**
*Scotinophara lurida*, on rice in India, **174.**
*scotti, Rhabdotohispa.*
*scutellata, Sturmia.*
*scutigera, Platyedra* (*Pectinophora*).
*Securidaca longepedunculata*, new Coccid on, in S. Rhodesia, **355.**
*securidacae, Aspidiotus* (*Hemiberlesia*) *zizyphi.*
*Selenaspidus articulatus* (see *Aspidiotus*).
*Selenothrips* (*Heliothrips*) *indicus*, **69, 71;** food-plants of, in India and Egypt, **78.**
*Selenothrips rubrocinctus*, **70, 71;** on cashew in India, **78.**
*semisimplicipes, Eretmopodites chrysogaster.*
*Senecio angulatus*, Trypetid on, in Natal, **397.**
*Senecio longiflora*, new Trypetid on, in S. Africa, **399.**
*septemfasciata, Nomadacris.*
*Sericothripoides*, gen. n. for *Dendrothrips bispinosus*, Bagn., **69.**
*Sericothripoides* (*Dendrothrips*) *bispinosus*, on tea in India, **79.**
*serinopa, Nephantis.*
*Sesamia cretica*, Braconid parasite of, in Sudan, **108.**
*Sesbania*, thrips on, in India, **78, 79.**
*setariae, Hystoneura.*
*setiventris, Taeniothrips.*
*sexdens, Atta.*
Seychelles, *Elasmus* spp. in, **412, 413, 415, 419.**
*seydeli, Anopheles theileri.*
*Shorea talura*, lac insect on, in India, **243.**
Sierra Leone, food-plants of thrips in, **70, 72, 74;** *Nysius albidus* in, **268.**
*signifera, Paratheresia.*
*Silvanus surinamensis*, natural enemies of, in Australia, **425–430.**
*silvestris, Eretmopodites.*
*similis, Aëdes.*
*simlensis, Anopheles gigas.*
*simplex, Aëdes* (*Cancraëdes*).
*sinensis, Anopheles hyrcanus.*
*singularis, Sahlbergella.*
*Sipha flava*, Cecidomyiid predacious on, **438.**
*sissoo, Disophrys.*
*sitiens, Culex.*

*Skusea*, species included in, **340–342**; a subgenus of *Aëdes*, *q. v.*
*Smilax*, Coccid on, in S. Rhodesia, **352.**
*smithi*, *Anopheles.*
Solomon Islands, new Hispids from, **233–239**; mosquitos from, **303–316.**
*solomonis*, *Culex* (*Lophoceratomyia*) *fraudatrix*; *Rachionotomyia.*
Somaliland, Italian, Coccid on *Capparis* in, **346.**
*sonchella*, *Macrosiphum.*
*sonchi*, *Isobremia*; *Macrosiphum*; *Rhopalosiphum.*
*Sonchus oleraceus*, Aphid on, in France, **434.**
*Sorghum*, thrips on, in India, **79**; bionomics and control of *Agonoscelis versicolor* on, in Sudan, **209–224.**
*soror*, *Haplothrips*; *Promecotheca.*
*sororcula*, *Wyeomyia.*
*sororculus*, *Haplothrips.*
*spatulata*, *Diaspis subregularis.*
*Spatulicraspeda castaneiceps*, wrongly identified as host of *Fornicia ceylonica* in Ceylon, **107.**
*sphaeristicus*, *Dacus.*
*Sphenarches caffer*, Braconid parasite of, in Sudan, **109.**
*Spilosoma* (see *Diacrisia*).
*Spinaspidiotus oceanica* (see *Furcaspis*).
*spinifera*, *Berlesaspis.*
Spruce, *Hylobius abietis* infesting, in Sweden, **245–250.**
*squamipennis*, *Aëdomyia.*
*stali*, *Nysius.*
*stanotophri*, *Chionaspis.*
*Stauropus*, Braconid parasite of, in India, **109.**
*Stegomyia*, a subgenus of *Aëdes*, *q. v.*
*steirastomae*, *Cyanopterus.*
*stellenboschensis*, *Eulimneria* (*Limneriun*).
*stenophyllae*, *Pseudaonidia.*
*stentor*, *Dacus.*
*stictica*, *Pardalaspis.*
*Stirastoma depressum*, Braconid associated with, in cacao logs in Trinidad, **205.**
*Stomatoceras exaratum*, parasite of *Glossina morsitans* in Nyasaland, **283**; in S. Rhodesia, **287, 384.**
*striata*, *Chionaspis.*
*striatifrons*, *Insizwa.*
*strobilobii*, *Adelgimyza.*
*strobilobius*, *Adelges.*
*Strobilotoma typhaecornis*, synonymy of, **269.**
*stultalis*, *Psara.*
*Sturmia scutellata*, **459.**
*Stylothrips brevipalpis*, on chrysanthemum in India, **79.**
*Styphelia*, Coccid on, in Australia, **27.**
*subfervens*, *Targionia.*
*subnivea*, *Lepidosaphes.*
*subochrea*, *Theobaldia.*
*subramanii*, *Kleothrips.*
*subregularis*, *Diaspis.*
*subrossi*, *Aspidiotus* (*Aonidiella*).
*subrubescens*, *Aspidiotus.*
*subsimplicipes*, *Eretmopodites chrysogaster.*
*subterranea*, *Monobremia.*
*subtilissimus*, *Haplothrips.*
*subvisci*, *Chionaspis* (*Dinaspis*).
Sudan, bionomics and control of *Agonoscelis versicolor* on *Sorghum* in, **209–224**; Braconid parasites from, **106, 108, 109**; poison bait against locusts in, **99–101**; new Chalcidoid parasites from, **257, 259**; thrips on cotton in, **73.**
*sudanensis*, *Rhaconotus.*
Sugar-cane, *Diatraea saccharalis* on, in Argentina, **200**; new Hispid on, in Brazil, **89**; control of *Castnia licoides* on, in Br. Guiana, **192**; *Scirpophaga intacta* on, in Java, **418**; pests of, in Peru, **228, 229, 230**; thrips on, in India, **79.**
*sulphurea*, *Frankliniella.*
Sunn Hemp (see *Crotalaria juncea*).
*superba*, *Carpophthoromyia.*
*surinamensis*, *Silvanus.*
Sweden, methods of investigating fauna of tree stumps in, **245–250.**
Sword Bean (see *Canavalia ensiformis*).
*swynnertoni*, *Glossina.*
*Sylepta derogata*, parasites of, in E. Africa, **112, 420**; Chalcid parasites of, in India & Malaya, **413, 415**; parasites of, in Philippines, **256, 413.**
*syleptae*, *Apanteles*; *Elasmus.*
*symphyti*, *Aphis.*
*Synopeas rhanis*, parasite of *Isobremia kiefferi*, **434.**
*Syntomosphyrum glossinae*, parasite of *Glossina morsitans* in Africa, **283, 383, 384**; bionomics of, in S. Rhodesia, **287–288, 297, 299.**
*syringae*, *Poliaspis.*

## T.

*tabaci*, *Thrips.*
*tabaniformis*, *Glossina.*
*tachinoides*, *Glossina.*
*Taeniorhynchus*, characters of squama of, **343.**
*Taeniorhynchus uniformis*, **304.**
*Taeniothrips distalis*, food-plants of, in India, **78.**
*Taeniothrips jonnaphila*, food-plants of, in India, **79.**

*Taeniothrips lefroyi*, on tea in India, **78.**
*Taeniothrips longistylus*, food-plants of, in India, **78.**
*Taeniothrips setiventris*, on tea in India, **78.**
*Tanacetum vulgare*, **436**; Aphid on, in Italy, **440.**
Tanganyika Territory, new Hymenopterous parasites from, **112, 257**; thrips on coffee & onion in, **73, 76.**
*taprobanae, Apanteles.*
*taragamae, Apanteles.*
*Targionia*, on sugar-cane in Peru, **229.**
*Targionia acaciae*, on *Acacia stenophylla* in Australia, **28, 29.**
*Targionia subfervens*, food-plants of, in Australia, **29.**
*tarsalis Aëdes* (*Aëdimorphus*).
*tarsatus, Eupelminus.*
Tasmania, new Coccid on *Acacia* in, **35.**
Tea, *Homona coffearia* on, in Ceylon, **416**; thrips on, in India, **78, 79.**
Tea Bagworm (see *Psyche albipes*).
Technique, methods of, applicable to entomology, **165–171.**
*Tectona grandis*, pests of, in India, **109, 413.**
*tectonae, Aspidiotus.*
*tenuidisculus, Chionaspis.*
*tenuipennis, Haplothrips.*
*Terastia meticulosalis*, Braconid parasite of, in India, **111.**
*Terminalia*, thrips on, in India, **78**; Coccid on, in S. Rhodesia, **365.**
*tessellata, Octotoma.*
*tesserata, Pseudaonidia.*
*Tetrastichus*, parasite of *Lema melanopa* in Britain, **10.**
*Tetroda histeroides*, bionomics and control of, on rice in S. India, **173–178.**
*texana, Anomis.*
*theileri, Anopheles.*
*Thelaxes dryophila*, Cecidomyiid predacious on, in France, **439.**
*Theobaldia*, characters of squama of, **343.**
*Theobaldia annulata*, instar records of, **195–198.**
*Theobaldia subochrea*, **197, 198.**
*theobromae, Ischnotrachelus.*
*therapon, Castnia.*
*theridii, Microstigmus.*
*Therioaphis ononidis*, Cecidomyiid predacious on, in U.S.A., **435.**
*thrax, Evionota.*
*Thrips florum*, food-plants of, in India, **79.**
*Thrips nilgiriensis*, on orange in India, **79.**
*Thrips oryzae*, on rice in India & Far East, **77.**
*Thrips palmi*, food-plants of, in India, **79.**
*Thrips pandu*, on citrus in India, **79.**
*Thrips tabaci*, food-plants of, in India, **78.**
*Thyridanthrax*, key to species of, parasitic on *Glossina*, **151**; parasites of *Glossina morsitans* in S. Rhodesia, **283, 285, 384**; bionomics of, **285–286.**
*Thyridanthrax abruptus*, **285**; parasite of *Glossina morsitans* in Africa, **157.**
*Thyridanthrax argentifrons*, sp. n., parasite of *Glossina* spp. in N. Nigeria, **155.**
*Thyridanthrax beneficus*, sp. n., parasite of *Glossina morsitans* in Portuguese E. Africa, **162.**
*Thyridanthrax lineus*, parasite of *Glossina morsitans* in Africa, **161.**
*Thyridanthrax lloydi*, parasite of *Glossina morsitans* in N. Rhodesia, **152.**
*Thyridanthrax lugens* (see *T. abruptus*).
*Thyridanthrax salutaris*, sp. n., parasite of *Glossina morsitans* in Nyasaland, **154.**
*Thyridanthrax transiens*, parasite of *Glossina morsitans* in Nyasaland, **160**; further description of, **160.**
Thysanoptera, economic status of, in India, **77–79**; feeding habits of, **77.**
Tibet, new mosquito from, **323.**
Tiger-beetle, habits of larva of, in N. Nigeria, **403–406.**
*Tillandsia*, **225.**
*Tinea*, Chalcid parasite of, in India, **416.**
*Tiphia*, parasite of *Polyphylla fullo* in Ukraine, **96.**
*tiracholae, Apanteles.*
Tobacco, thrips on, in India, **78**; *Phthorimaea* on, in Mauritius, **104.**
*tongae, Aëdes variegatus.*
*tonsus, Aëdes* (*Geoskusea*).
*Topomyia*, characters of squama of, **343.**
*Toxoptera*, natural enemies of, in Italy, **439.**
*Toxoptera graminum*, Cecidomyiid predacious on, **438.**
*toxopterae, Guerciobremia.*
*transiens, Thyridanthrax.*
*trapezalis, Marasmius.*
Tree-stumps, method of investigating fauna of, **245–250.**
*Trichogramma*, **143.**
*Trichogramma minutum*, parasite of *Diatraea saccharalis* in Peru, **228.**
*Trichoprosopon*, characters of squama of, **343.**
*trichopus, Goeldia.*
*Tridacus* (see *Dacus*).

*trifolii, Callipterus* (see *Therioaphis ononidis*).
*Trilobia aphisuga*, predacious on Aphids in Italy, **434.**
Trinidad, new Sphegid from, **407.**
*trirhoda, Hyalopterus.*
*tristis, Lema.*
*truncata, Phragmatiphila.*
*tryoni, Diachasma.*
*Trypanea lignoptera*, sp. n., on *Berkheya magaliesmontana* in S. Africa, **399.**
*Trypanosoma* spp., incidence of, in *Glossina morsitans* in S. Rhodesia, **384, 390.**
Trypetidae, new species of, from S. Africa, **391 400.**
*Tryphactothrips rutherfordi*, food-plants of, in India, **79.**
Tsetse-flies (see *Glossina*).
*tuberculata, Chionaspis* (*Pinnaspis*).
*tuberculatus, Aspidiotus.*
*tucumana, Aulatopria.*
*tulagiensis, Aëdes edwardsi.*
*tulliae, Aëdes* (*Chaetocruiomyia*).
Turmeric, thrips on, in India, **79.**
*Tylodes insubidus*, **203.**
*Tylodes vellericollis*, sp. n., on cacao in Brazil, **202.**
*typhaecornis, Strobilotoma.*

## U.

*Uapaca* spp., new Coccids on, in S. Rhodesia, **389, 374.**
*uapacae, Chionaspis* (see *C. dura*).
Uganda, new Hymenopterous parasites from, **104, 112, 207, 257, 447**; Coccid in, **346.**
Ukraine, bionomics and control of Scarabaeids attacking vines in, **95-98.**
*umbrosus, Aëdes.*
*umtalii, Aspidiotus* (*Hemiberlesia*) *rhodesiensis*; *Chionaspis* (*Phenacaspis*) *visci.*
*Uncinulella eriosomiperda*, predacious on Aphid in Italy, **434.**
*uniannulata, Aëdes* (*Neopecomyia*).
*uniformis, Taeniorhynchus.*
*unipuncta, Cirphis.*
United States of America, Cecidomyiids predacious on Aphids in, **434, 435-438, 440**; parasite of *Galleria mellonella* in, **430**; hosts of *Microdontomerus anthonomi* in, **255.**
*Uranotaenia*, characters of squama of, **343.**
*Uranotaenia albescens*, in Solomon Is., **304.**
*Uranotaenia argyritarsis*, in Solomon Is., **305**; male & pupa of, **312.**
*Uranotaenia bimaculata*, **314.**
*Uranotaenia inornata*, **60.**
*Uranotaenia mashonaensis*, **314.**
*Uranotaenia nigerrima*, **313, 314.**
*Uranotaenia nigripes*, early stages of, **59.**
*Uranotaenia obscura*, **313.**
*Uranotaenia quadrimaculata*, sp. n., from Solomon Is., **304, 313.**
*urticaria, Aphis.*
*urticariae, Phaenobremia.*

## V.

*vacunae, Phaenobremia.*
*variabilis, Hypera.*
*variegatus, Aëdes* (*Stegomyia*).
*varipes, Brachymeria* (*Chalcis*); *Dolichothrips.*
*vastatrix, Phylloxera.*
*vellericollis, Tylodes.*
*venustipes, Aëdomyia.*
*Vernonia podocoma*, new Coccid on, in S. Rhodesia, **351.**
*vernoniae, Aspidiotus.*
*Veronica*, Coccid on, in Australia, **27.**
*versicolor, Agonoscelis.*
*vestitus, Anthonomus.*
*vexans, Aëdes* (*Aëdimorphus*).
*vichitravarna, Rhynchothrips.*
*Vicia faba*, Aphids on, in Italy, **434.**
*Vigna catjang* (Cow-pea), thrips on, in India, **79.**
*villosa, Anoxia.*
Vines, thrips on, in India, **78**; bionomics and control of Scarabaeids on, in Ukraine, **95 98.**
*violacea, Diplosis.*
*viridipennis, Ischnotrachelus.*
*visci, Chionaspis* (*Phenacaspis*).
*vittator, Opius.*
*vivax, Trypanosoma.*

## W.

*walkeri, Acanthiophilus.*
*watsoni, Anopheles.*
*wattensis, Aëdes* (*Chaetocruiomyia*).
Wattle, Black (see *Acacia mollissima*).
West Indies, Braconid associated with *Stirastoma depressum* in cacao logs in, **205**; *Dysdercus andreae* on cotton in, **227.**
Wheat, food-plant of *Lema melanopa* in Britain, **9.**
Woolly Aphis (see *Eriosoma lanigerum*).
*Wyeomyia*, characters of squama of, **343.**
*Wyeomyia sovorcula*, **308.**

## Y.

Yellow Fever, experimentally transmitted by *Eretmopodites chrysogaster*, **328.**
*ypsilon, Agrotis.*

## Z.

*zealandicus, Rhypodes* (*Nysius*).
*zehntneri, Elasmus.*
*Zeugmatothripoides*, gen. n., **71.**
*Zeugmatothripoides africana*, sp. n., on kola in Sierra Leone, **72.**
*Zeugmatothrips*, **71, 72.**
*Zeugnomyia*, characters of squama of, **343.**
*zizyphi, Aspidiotus* (*Hemiberlesia*); *Aspidiotus combreti.*
*Zizyphus jujuba*, new Coccids on, in S. Rhodesia, **347, 354, 375.**

# INDEX TO NAMES OF PERSONS.


Alcock, A., **403.**
Aldrich, J. M., **199, 200.**
Alexander, M. L., **227.**
Austen, E. E., **1, 151.**
Averin, V. G., **5.**

Back, E. A., **246.**
Bagnall, R. S., **69, 433, 434, 439, 440.**
Bahadur, U., **259, 414.**
Bailey, F. M., **323.**
Ballard, E., **108, 110.**
Barber, T. C., **199.**
Barclay, A. H., **159.**
Barnes, H. F., **119, 433, 438.**
Barritt, N. W., **41, 44.**
Beattie, M. V. F., **45.**
Bedford, H. W., **73, 106, 414.**
Beeson, C. F. C., **107, 109, 453, 454.**
Bergenstamm, J. E. v., **435.**
Berlese, A., **166.**
Bezzi, M., **151, 391, 392, 396, 397.**
Bishara, I., **41.**
Bissell, T. H., **148.**
Bodkin, G. E., **123, 192, 431.**
Bondar, G., **86, 88, 89, 90, 94, 203, 204.**
Bose, M., **107.**
Bovien, P., **119.**
Box, H. E., **161, 199.**
Brain, C. K., **345.**
Brair, J. H., **431.**
Brauner, A. A., **97.**
Breinl, A., **314.**
Brèthes, J., **199.**
Britten, H., **438.**
Brohier, E. L., **322.**
Browne, G. St. J. O., **161.**
Bryant, G. E., **202, 399.**
Burgst, C. A. L. Smits van, **430.**
Busck, A., **181, 185.**
Buxton, P. A., **40, 50, 51, 57, 305, 315, 338, 403.**

Cameron, P., **411.**
Cameron, W. P. L., **224, 322.**
Candura, G., **120.**
Carew, W. D., **338.**
Carment, A. C., **304.**
Charmoy, D. d'Emmerez de, **108.**
Chatterjee, S. N., **109, 111, 241, 413, 414.**
Cherian, M. C., **415.**
Cherrett, B. W., **159, 162.**
China, W. E., **38, 253, 270.**
Chorley, J. K., **279, 377.**
Christophers, S. R., **56.**
Clark, J., **427.**
Clezio, E. Le, **403, 405.**
Cole, A. E., **50.**
Connal, A. C., **59, 331.**
Cooling, L. E., **277, 310, 315.**
Corbett, G. H., **74, 113, 409, 413, 415.**
Cotterell, G. S., **201, 254.**
Cotton, R. T., **246.**
Cowland, J. W., **257, 414.**
Crawford, D. L., **411.**
Cuthbertson, A., **286.**

Darling, R. C., **108.**
Davidson, J., **166.**
Davis, J. J., **433, 437, 438.**
de Charmoy, D. d'Emmerez, **108.**
Dekhtiarev, N. S., **95, 96** (note).
Delafield, E. M., **51.**
Del Guercio, G., **434.**
d'Emmerez de Charmoy, D., **108.**
Descourtils, **204.**
Dixon, J. E., **20–23, 26–29, 34.**
Duren, A. N., **325.**
Dutt, G. R., **208.**
Dyar, H. G., **246, 271.**

Edwards, F. W., **51, 56, 59, 67, 271, 303, 308, 321.**
Edwards, W. H., **104.**
Elliott, H. E., **227.**
Esben-Petersen, P., **263.**
Evans, J. W., **267.**

Farajallah, B. S., **135, 431.**
Fawcett, W., **192.**
Felt, E. P., **437, 438, 440.**

Ferrière, C. **104, 255, 411.**
Ferris, G. F., **168.**
Feytaud, J., **6.**
Fiske, W. F., **141, 142, 461.**
Fletcher, T. B., **77, 111.**
Florence, L., **169.**
Forbes, W. T. M., **179** (note), **181** (note).
French, C., **15, 17, 21, 25, 29, 34.**
Fritsch, F. E., **54, 57.**
Froggatt, W. W., **15, 17, 21, 26, 36, 37.**
Fry, A., **204.**
Fuller, C., **293, 345.**

Gahan, A. B., **107, 108, 411.**
Gardner, J. C. M., **111.**
Genieys, P., **425.**
Girault, A. A., **411.**
Given, D. H. C., **59.**
Golding, F. D., **38.**
Golledge, C. J., **224.**
Golovyanko, Z. S., **98.**
Gordon, R. M., **59.**
Gough, L. H., **41, 322.**
Graham, W. M., **327.**
Green, E. E., **15–17, 24–26, 29, 30, 33, 36, 170, 346, 356, 357, 359, 362–365, 370.**
Grünberg, K., **192.**
Guercio, G. Del, **434.**

Hacker, H. P., **323.**
Haley, W. E., **199.**
Hall, D. G., **199** (note).
Hall, W. J., **345, 359.**
Hancock, G. L. R., **104, 112, 207, 257, 322.**
Hänsel, S., **6.**
Hargreaves, E., **71, 73, 75.**
Hargreaves, H., **447.**
Harris, H. R., **227.**
Harris, R. H., **280, 394.**
Harrison, J. W. H., **433, 434, 439, 440.**
Hart, T. S., **31.**
Hase, A., **425.**
Heinrich, C., **181.**
Hendel, F., **391, 395.**
Hewitt, J., **417.**
Heydon, **314.**
Hill, G. F., **15–17, 21, 24–27, 29, 30, 33, 36, 37.**
Hillman, H., **71.**
Hinds, W. E., **226.**
Hodson, W. E. H., **5.**
Holdaway, F. G., **179.**
Holloway, T. E., **199.**
Hopkins, G. H. E., **50.**
Houlbert, C., **192.**
Howard, L. O., **141.**
Howland, L. J., **45, 46.**
Hulley, L. S., **392, 394.**
Husain, Afzal, **206.**
Hutson, J. C., **412, 418.**

Ikeda, T., **6.**
Imms, A. D., **165, 241.**
Ingram, A., **59, 322, 332.**

Jack, R. W., **158, 285, 293.**
Jackson, D. J., **437.**
James, S. P., **63.**
Jenkins, J. R. W., **6.**
Johannsen, O. A., **181** (note).
Johnson, W. B., **322, 384, 403.**
Johnston, H. B., **108, 259, 414.**
Jolles, P., **133, 135.**
Jordan, H., **406.**

Kadocsa, G., **5.**
Kalshoven, L. G. E., **202.**
Karstens, E. E., **50.**
Kelly, R., **15, 23, 27.**
Kent, C. C., **395.**
Khan, D. H., **206.**
Kieffer, J. J., **433, 435.**
Kimmins, D. E., **233.**
King, H. H., **99, 209.**
Knab, F., **199.**
Krishna Ayyar, P. N., **173.**
Kulagin, N. M., **5.**

Laing, F., **15, 433.**
Lamborn, W. A., **155, 158, 160, 162, 281–283, 287, 420, 421, 444.**
Lathy, P. I., **192.**
Le Clezio, E., **403, 405.**
Lefroy, H. M., **77.**
Lengerken, H. v., **404, 405.**
Leonardi, G., **15, 29, 30.**
Light, S. S., **107, 416.**
Lindner, E., **391.**
Lloyd, Ll., **153, 158, 281–283, 377, 384.**
Loew, P., **435.**
Loftin, U. C., **199.**
Lyon, A. V., **426, 427.**

McDougall, W. A., **108.**
McEuen, E. S., **196.**
Macfie, J. W. S., **59, 60.**
MacGillivray, A. D., **15, 30.**
MacGregor, M. E., **50.**
McHardy, J., **325, 329** (note).
Mahdihassan, S., **241.**
Marlatt, C. L., **192.**
Marshall, G. A. K., **35, 69, 158** (note), **201.**
Marshall, J. F., **195.**
Masi, L., **411.**

Maskell, W. M., **15, 30.**
Mason, C., **420.**
Mathur, R. N., **453, 454.**
Maulik, S., **81, 233.**
Maw, W. A., **323.**
Mayer, T. F. G., **322.**
Mayné, R., **446.**
Megalov, B., **5–7, 12.**
Mell, R., **206.**
Meyrick, E., **181.**
Misra, C. S., **418.**
Morley, C., **430.**
Morrison, H., **229.**
Mossop, M. C., **394.**
Muir, F., **409.**
Munro, H. K., **114, 345, 391, 398, 399, 401.**
Munro, J. W., **169** (note).
Murata, J., **6.**
Murray, D. P., **105.**
Myers, J. G., **205, 408, 425.**

Nachtrier, H. F., **170.**
Neave, S. A., **322, 445, 448, 450.**
Negi, P. S., **241.**
Newstead, R., **4.**

Osborn, H. T., **438.**
Owen, H. B., **159.**

Paine, R. W., **234, 239, 303, 304, 308, 337, 339, 340.**
Pampel, W., **169.**
Paramonow, S. J., **151** (note).
Pemberton, C. E., **142, 146, 147.**
Philip, C. B., **327.**
Philippi, R. A., **192.**
Pierce, F. N., **181.**
Pierce, W. D., **229.**
Plotnikov, V. I., **261.**
Plumridge, C., **19.**
Pollard, J., **403.**
Pomeroy, A. W. J., **446.**
Pope, J. B., **227.**
Portier, P., **406.**
Predtechensky, S. A., **261, 262, 263.**

Ramachandra Rao, Y., **40, 109, 113, 185, 415.**
Ramakrishna Ayyar, T. V., **77.**
Ramsden, W., **50.**
Reyne, A., **83, 85, 192.**
Richmond, R. G., **430.**
Ritchie, A. H., **73, 76, 257.**
Rodway, F. R., **15, 25.**
Rohwer, S. A., **411.**
Rondani, C., **433, 435.**
Rosenfeld, A. H., **199.**
Ross, W. A., **438.**
Rothschild, Lord, **192.**
Rübasamen, E. H., **435.**

Salt, G., **187.**
Saunders, J. T., **51.**
Sayers, E. G., **305, 306, 308, 315.**
Schaus, W., **192.**
Schiödte, J. C., **403.**
Scholefield, S. W. J., **158.**
Schulze, H., **425.**
Schwetz, J., **1, 4, 62** (note), **324, 327–331, 333, 334.**
Scott, H., **39.**
Senior White, R., **50.**
Seydel, C., **322.**
Sharp, N. A. Dyce, **403.**
Showell, H., **425, 428.**
Silvestri, F., **142, 146.**
Simanton, F. L., **246.**
Simmonds, H. W., **256.**
Simpson, J. J., **158** (note).
Simpson, T., **322.**
Singh, A., **206.**
Sjöstedt, Y., **158, 162** (note).
Skuse, F. A. A., **440.**
Smith, A., **159.**
Smith, H. S., **141, 461.**
Smits van Burgst, C. A. L., **430.**
Staley, J., **195.**
Stevenson, R. H. R., **394.**
Stohr, F. O., **158.**
Strand, E., **192.**
Svenningsen, S. A., **192.**
Swynnerton, C. F. M., **164, 282, 377.**

Taylor, F. H., **271, 273, 275, 276.**
Terzi, A. J. E., **81.**
Thomasset, H. P., **162.**
Thompson, W. R., **142, 433** (note), **457.**
Tobin, D. E., **227.**
Tothill, J. D., **169, 234, 237.**
Townsend, C. H. T., **199, 226, 228, 229.**
Trägärdh, I., **245.**
Trehan, K. N., **208.**
Turner, A. J., **181.**
Turner, R. E., **269, 407.**

Uvarov, B. P., **5, 123** (note), **261, 264.**

v. Bergenstamm, J. E., **435.**
v. Lengerken, H., **404, 405.**
van Burgst, C. A. L. Smits, **430.**
Vassiliev, E. M., **5, 11.**
Vereshtchagin, B., **5.**
Voukassovitch, P., **433** (note).

Walton, C. L., **6.**
Waterston, J., **428.**
Watson, Sir M., **322.**
Weisman, C., **133.**
Weiss, H. B., **192.**
Wesché, W., **59.**
West, G. S., **54.**
Whitfield, F. G. S., **209.**
Wigglesworth, V. B., **59, 156, 403.**
Wilkinson, D. S., **103, 205, 443.**
Willard, H. F., **142, 146–148.**
Williams, C. B., **41.**
Williams, F. X., **438.**
Williamson, K. B., **48, 50.**
Wolcott, G. N., **192, 225.**
Woolman, C. E., **227.**

Zikan, J. J., **403.**
Zolotarevsky, B. N., **261, 262.**

---

DATES OF PUBLICATION IN PARTS

Part **I** pp. 1–118 ... **2** June, **1929.**
Part **II** pp. 119–252 ... **23** August, **1929.**
Part **III** pp. 253–358 ... **15** October, **1929.**
Part **IV** pp. 359–464 ... **14** December, **1929.**